Maintenance of Way Cyclopedia

A REFERENCE BOOK

Covering

Definitions, Descriptions, Illustrations and Methods of Use of the Materials, Equipment and Devices Employed in the Maintenance of the Tracks, Bridges, Buildings, Water Stations, Signals and Other Fixed Properties of Railways.

Compiled and Edited by

E. T. HOWSON, Western Editor of the *Railway Age*, and Editor of the *Railway Maintenance Engineer*,

E. R. LEWIS, Formerly Chief Engineer of the Duluth, South Shore & Atlantic, and

K. E. KELLENBERGER (Signal Section), Editor of the *Railway Signal Engineer*,

Assisted by

HOMER HUGHES, Associate Editor, Formerly Assistant Field Engineer, Interstate Commerce Commission

IN CO-OPERATION WITH THE
AMERICAN RAILWAY ENGINEERING ASSOCIATION
COMMITTEE

H. R. SAFFORD, *Assistant to the President, Chicago, Burlington & Quincy*
L. A. DOWNS, *Vice President and General Manager, Central of Georgia*
G. H. BREMNER, *District Engineer, Division of Valuation, Interstate Commerce Commission*

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Preface

This volume is designed to present in alphabetical order for the readiest reference the definitions, descriptions, illustrations and methods of use of the materials, devices and equipment employed in the maintenance of the fixed properties of railways. A great deal of the data presented in this Cyclopedia has not been published elsewhere and no comparable compilation has ever before been undertaken. Such literature as heretofore has been prepared descriptive of maintenance of way devices is variously presented in so many books that a comprehensive library between the covers of one volume, concise in arrangement is here offered in the belief that it will afford the busy reader the desirable information in the handiest form, on a wide variety of maintenance of way subjects.

The names by which men know many of these devices and their parts are at present confused on account of duplications in local usages, which in some cases have been so persistent that purchases can be made intelligently only on the basis of individual correspondence. This confusion of terminology is eliminated as far as possible in this volume, the editors having co-operated with the American Railway Engineering Association and allied technical associations in the adoption and use of preferred terms. In general the nomenclature of the Manual of the American Railway Engineering Association has been accepted, although in a few cases better known trade names have been substituted.

The volume includes the latest revisions of specifications adopted by the American Railway Engineering Association, The American Railway Association, The Railway Signal Association, The American Wood Preservers Association, and The Manganese Track Society. The names of these associations throughout the book are respectively abbreviated to A. R. E. A., A. R. A., R. S. A., A. W. P. A. and M. T. S.

The illustrated text of the Cyclopedia is divided into sections treating of (1) Track, (2) Bridges, (3) Buildings, (4) Water Service, (5) Signals, (6) Wood Preservation and (7) General Subjects. This treatment is general, dealing with classes of appliances rather than with individual devices.

The Catalog section contains more detailed information on specific contrivances, designed to supplement the Illustrated Text, to afford the reader exact details and to help him to select from a class, the device best suited to his use. This section has been written and edited by the engineering experts of the Simmons-Boardman Copy Service department, with the assistance, advice and hearty co-operation of the manufacturers represented.

The editors desire to express appreciation to the American Railway Engineering Association for the many courtesies extended, for the free use of matter appearing in its Manual and Proceedings as well as for information made available through the hearty co-operation of its officers and members. They are particularly indebted to the committee appointed by this Association to co-operate in the publication of this volume, consisting of H. R. Safford, assistant to the president, Chicago, Burlington & Quincy, Chicago, chairman; L. A. Downs, vice-president and general manager, Central of Georgia, Savannah, Ga., and George H. Bremner, district engineer, Division of Valuation, Interstate Commerce Commission, Chicago.

Acknowledgments and thanks are also due to the following persons for their generous contributions of time and labor and their valuable assistance rendered in reviewing the text sections:

E. A. Harrison, Architect, Atchison, Topeka & Santa Fe, Chicago; Building Section.

C. R. Knowles, Superintendent of Water Service, Illinois Central, Chicago; Water Service Section.

H. K. Lowry, Signal Engineer, Chicago, Rock Island & Pacific, Chicago; Signal Section.

C. M. Taylor, Superintendent of Creosoting Plants, Philadelphia & Reading and Central of New Jersey, Port Reading, N. J.; Wood Preservation.

C. W. Gennet, Jr., Manager Rail Inspection Department, Robert W. Hunt & Co., Chicago; Metallurgy.

W. S. Lacher, Western Engineering Editor, Railway Age, Chicago; Bridge Section.

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ERRATA

In publishing the Maintenance of Way Cyclopedia every reasonable precaution was adopted to eliminate errors and to insure the accuracy of the contents. In an undertaking of this magnitude it is, however, seldom, if ever, possible to eliminate all errors. Since this cyclopedia has come from the press certain inaccuracies and mistakes have been detected. In furtherance of our endeavor to make this volume entirely accurate we indicate below corrections which should be made.

SIMMONS-BOARDMAN PUBLISHING COMPANY.

Page 36.—The caption under the third illustration from the top in the right hand column should read:

Kalamazoo Section Car
The Kalamazoo Railway Supply Co.
(See Page 726)

Page 37.—The caption under the first illustration at the top of the right hand column should read:

Mudge Inspection Motor Car
Mudge & Co.
(See Page 750)

Page 96.—The caption under the second illustration from the top of the right hand column should read:

Morden Guard Rail Clamp
The Morden Frog & Crossing Works
(See Page 752)

Page 97.—The caption under the third illustration from the top in the left hand column should read:

Guard Rail Clamp
The Pettibone Mulliken Co.
(See Page 773)

Page 113.—The caption under the illustration at the bottom of the right hand column should read:

Reliance Lock Washer
The Reliance Manufacturing Co.
(See Page 790)

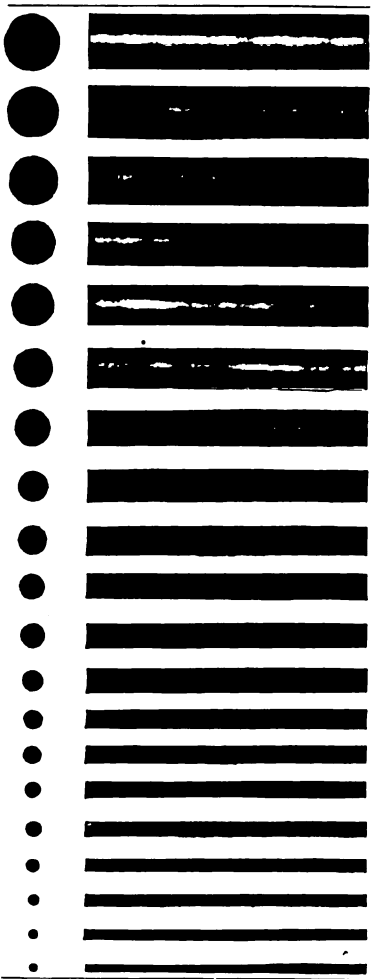
Page 127.—The tables showing mill practice in branding and heat number stamping of steel rails were revised and corrected from similar tables published in a copyrighted booklet by the Railroad Supply Company.

Page 171.—The caption under the illustration near the top of the page should read:

Three Throw Split Switch
The Frog, Switch & Manufacturing Co.

Page 623.—Substitute the following for a similar table in the right hand column:

SMOOTH STEEL WIRES

Cuts showing exact sizes of No. 1 to No. 20 gage steel wire by American Steel & Wire Company gage.	Gage	Lb. to Mile	Feet to 1 Lb.
	1	1121	4.71
	2	968	5.45
	3	833	6.34
	4	707	7.47
	5	599	8.81
	6	514	10.28
	7	439	12.05
	8	367	14.37
	9	306	17.24
	10	255	20.70
	11	202	26.18
	12	154	34.25
	13	118	44.64
	14	89	59.17
	15	72	73.00
	16	55	95.24
	17	41	129.87
	18	31	172.11
	19	24	222.22
	20	17	312.50

Steel Wire Gage

Page 647.—Title for the second table from the bottom should read:

Special Flexible Hoisting Rope—6 Strands, 37 Wires to the Strand, 1 Hemp Core

Title for the table at the bottom of the page should read:

Extra Special Flexible Hoisting Rope—6 Strands, 61 Wires to the Strand, 1 Hemp Core

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How to Use the Book

In preparing the Maintenance of Way Cyclopedia it has been the aim of the editors to present in the simplest terms and in the most convenient grouping information concerning a wide variety of subjects, of interest alike to the railway employee, to the division officer in direct charge of maintenance, to the operating officer vitally interested in and having supervision over but not in intimate touch with the materials and methods of maintenance, to the purchasing agent who must know the materials used in this field and to the engineer or manufacturer engaged in a pursuit closely allied with the railway industry.

The thought has been to select that which is representative of the best in the maintenance of way field, to incorporate the most modern methods, to include those standards bearing the approval of the prominent technical societies and to show those devices which have been proved to be of undoubted value.

The wholehearted approval of these ideals by railway men and their earnest desire for this authoritative and convenient reference book is evidenced by the co-operation of the American Railway Engineering Association and allied technical societies, and of their officers and members, as well as more than 130 of the leading manufacturers of maintenance of way equipment and materials represented in the Catalog section, who are especially interested in maintaining the high regard in which the world holds American railway manufactures and methods.

Withal, the editors have adhered strictly to the literary treatment which they deem of most value to the reader who has practical problems to solve and who seeks authoritative information on which he may safely stake his business reputation without loss of prestige or waste of time. The aim has been to make the diction clear, the terms plain and the text within the understanding of all readers. It is written for the roadmaster and for men in comparable positions in other departments of maintenance of way as well as for their superiors.

The volume is composed of two general divisions, the Illustrated Text and the Catalog section. The Illustrated Text is further separated into sections corresponding with the several subdivisions of maintenance of way work, including Track, Bridges, Buildings, Water Service, Signals and Wood Preservation. These sections appear in the order named, while a General section, the last of the seven subdivisions of the Illustrated Text, includes the many devices commonly used in several or all of the preceding six subdivisions. Each section is arranged in complete alphabetical order the text being interspersed with more than 2500 illustrations of the appliances described.

The division engineer in charge of the maintenance of signals on his territory or the master carpenter responsible for station buildings will turn directly to the Signal section and the Building section respectively for the information he requires, as will the general officer who, though not directly in touch with departmental details, is intimately acquainted with his organization in all its branches, vitally interested in all matters pertaining to it, and responsible for the articles, the materials and the methods of maintenance in use under his jurisdiction. Railway men of other countries unfamiliar with American maintenance practice will find the simplified text surrounding the corresponding illustrations, of especial value in their investigations of appliances and methods not well known to them. All of these men appreciate the value of time, and its conservation is exemplified by the sectionized text of this volume, supplemented by the detailed descriptions of the Catalog pages.

Throughout, the text is interspersed with illustrations, of which there are more than 2500 in the book. Below the name of each illustration in the text are page numbers in the Catalog section where the device is further described and illustrated in such detail as is required by those who must have intimate knowledge of its applicability to their individual needs.

In using the Cyclopedia the reader is thus referred automatically and naturally from the name and definition to the description, the methods of use and the general appearance of the devices of the class he seeks; to the number of the page in the Catalog section where the device he has selected as most suitable for his needs is described authoritatively and in such detail as engineering experience has proved to be of most value.

In order to place before the users in unmistakably convenient reach every subject treated, a General Index is presented on the first few pages immediately following which includes in a single alphabetical assembly all the subjects treated in all sections in the book.

With a view to the further guidance of readers directly interested in the products described in the Catalog pages, three additional indexes are placed at the end of the Catalog section: (1). An Alphabetical Index of Catalogs, (2). Trade Name Index and (3) a Directory of Products.

In the Alphabetical Index is found in alphabetical arrangement a list of firms represented in the Catalog section, supplemented by the numbers of the Catalog pages on which their products are described. The Trade Name Index presents the trade names of the products shown in the Catalog section, arranged in alphabetical order. The firm name of the manufacturer of the product is given after each trade name with the page numbers in the Catalog section where the device is described in detail. Many products are best known by their trade names and the object of this index is to identify these products, many of which are not closely linked with the names of the manufacturers.

The last of these indexes is a Directory of Products, an alphabetical list of the products of the firms represented in the Catalog section and whose products appear in its pages.

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The
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A

ACTUAL POINT OF FROG. The point at which the spread between the gage lines of the intersecting running rails of a frog is sufficient to allow for a practical width of manufactured point, the standard width being ½ in. The actual point of frog is located back of the theoretical point or apex, a distance in inches equal to one-half the frog number. See Point, Half Inch (Frog). Also Point of Frog, Theoretical.

ACTUAL POINT OF SWITCH. The point where the spread between the center lines of the main track and the turnout is sufficient to allow for a practical switch point. The standard width of switch point is ¼ in. It is first planed to a line which makes it ¼ in. wide at the place known as the actual point. Thereafter it is ground from 2 ft. back of the actual point to a thickness of ⅛ in. at the actual point. The point is then finished to a sharp edge and ¼ round at the upper angle, within a radius of 1½ in.

ADJUSTABLE SEPARATOR (Guard Rail). A metal block of two or more parts fastened to and acting as a filler between the webs of the running rail and the guard rail and so designed as to provide varying widths of flangeway.

The adjustable separator is usually made of two wedge-shaped blocks with corresponding corrugated diagonal faces. These two blocks are placed so as to form a rectangle in plan, with the wavy diagonal surfaces representing the edges of the vertical corrugated faces fitted tightly together. The straight parallel sides of the separator fit against the adjacent sides of the main rail and the guard rail, and the top surface is hollowed to the contour of the flangeway. The corrugations on the wedge faces prevent the two parts from slipping while the two blocks are held in place by a clamp. The separator may be adjusted readily to any desired width by loosening the clamp sufficiently to permit the corrugations to pass each other.

When a guard rail is flange-worn it must be moved away from the frog point to maintain the correct gage. With an adjustable separator this wear can be overcome readily and economically. See Guard Rail.

AIR CHAMBER (Switch Lamp). The space provided above the lighting device in the top of a switch lamp for ventilating purposes.

Cold air entering the air chamber through inlets provided in the lamp top is deflected downward and outward toward the walls by a hollow ventilating cone hung above the flame or chimney, whence it is warmed by the flame, rises above it to the cone and passes out from the center of the air chamber through the outlet vent. See Cone, Ventilating.

ALINEMENT (Roadway). The horizontal location of a railway with reference to the curves and tangents. (A. R. E. A.)

The total length of tangent or straight track usually exceeds the total length of curved track, a common ratio being 75 per cent straight and 25 per cent curves, although these percentages are subject to as wide variation as the topography of the country traversed. In mountainous regions the percentage of total curvature frequently exceeds 40 per cent and sometimes is more than 50 per cent, while prairie lines with many miles of straight track have sometimes less than 10 per cent of curves.

Curves introduce elements of danger and expense as compared with straight track and are therefore to be avoided even at considerable cost for survey. Extra cost of construction to obtain a straight alinement depends on local circumstances, on the character of the railway, on the class of the material for grading and on the prospective traffic and maintenance.

The cost of maintaining curved track usually exceeds that of straight track, some of the principal items being the unequal wear on rail heads and wheels and the maintaining of super-elevation on the circular curve as well as on easement curves at the ends in order to avoid shocks due to sudden changes of motion which may be dangerous and are always unpleasant to passengers.

While there is usually a wide choice of alinement for the consideration of the locater of lines in comparatively level coutnry, a mountainous district usually offers only two or three feasible routes, the best of which may be readily determined.

ALINEMENT (Turnout). The location of a turnout with reference to the horizontal curves and tangents as laid out on the ground.

ANGLE BAR. A joint bar approximately angular in section, designed to fit against the web and upper surface of the flange of the rail. The horizontal leg of the angular section is usually bent down at the fishing angle of the rail to fit over the edge of the rail flange, while the extremity of the vertical leg which is designed to bear against the under side of the head of the rail is frequently enlarged to provide ample strength and bearing area. Present practice favors the angle bar on many American and foreign railways where it superseded the fish plate. It has, however, been modified by other styles of joint bars on a considerable number of roads with a view to obtaining stiffer supports for the rail ends. See Rail Joint. Also Joint Bar.

ANGLE (Frog). The angle between the intersecting gage lines of the point rails of the frog. The angles of frogs commonly used in railway work fall between 3 deg. and 10 deg. See Turnout. Also Frog, Turnout.

ANGLE (Turnout). The angle between the intersecting center lines of the main and turnout tracks at the frog point, measured in degrees, minutes and seconds.

ANTI-CREEPER. A device to prevent the creeping or longitudinal movement of rails in track under traffic. Its function is to hold the rail in a fixed position with reference to the tie. The anti-creeper is attached to the rail and either bears against the side of the tie or is spiked to it, thereby transmitting the creeping force to the tie and through it to the ballast.

An anti-creeper is usually made of one or two parts of malleable iron or steel. It is applied by bolting to the web of the rail, by engaging the base of the rail with a wedging or twisting action or by fastening to both the rail and the tie. It is sometimes made in combination with a tie plate.

Where the traffic is entirely or largely in one direction, it is common to apply anti-creepers to act in

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that direction only, although it is sometimes necessary to anchor tracks carrying traffic both ways against movement in either direction. The number of anti-creepers applied varies with the intensity of the force to be resisted, a sufficient number being installed to arrest the movement of the rail. Experience only will determine the number required in each case, although it is usual to apply the same number of anti-creepers per rail for considerable distances where conditions are similar.

When track is laid with broken joints and the joints are slot-spiked to the ties, the anti-creepers are first applied at the rail centers so that the anti-creepers equalize the anchoring effect of the slotted joint bars spiked to the ties. If more anti-creepers are required they are applied at the quarter points on both rails and at shorter intervals if necessary. Where rail is laid with square joints, anti-creepers are first installed at the rail centers and then at the quarters if required. It is commonly considered more economical to install anti-creepers when rail is being laid or renewed, when they will also help to retain the expansion allowance at the joints, although they can be applied at any time.

It is generally considered inadvisable to apply anti-creepers to rails on bridges because of the stresses which may be set up in the structures. It is better practice in general to place them on the approaches to the bridges where creeping prevails, to arrest the movement before it reaches the structures.

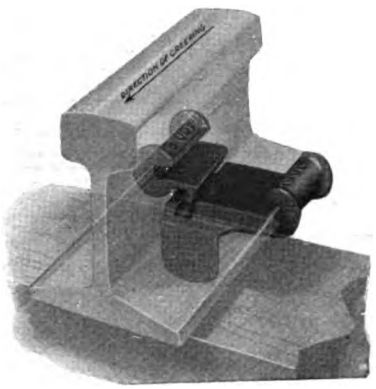
The general requirements of the A. R. E. A. for the design and manufacture of anti-creepers are as follows:

Anti-creepers shall be so designed as to fit two or more different weights of rail and so that they can be readily removed and re-applied.

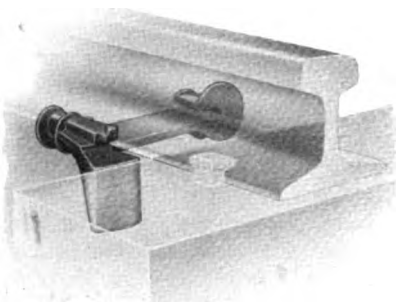
Ajax Anti-Creeper
The P & M Co.
(See Page 771)

C. R. S. Anti-Creeper
The Cleveland Railway Supply Co.

Efficiency Anti-Creeper
The Anchor Company

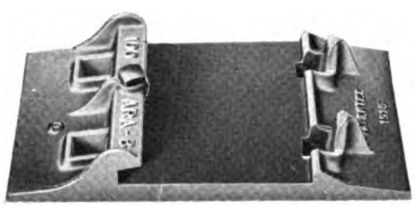


P & M Anti-Creeper
The P & M Co.
(See Page 770)

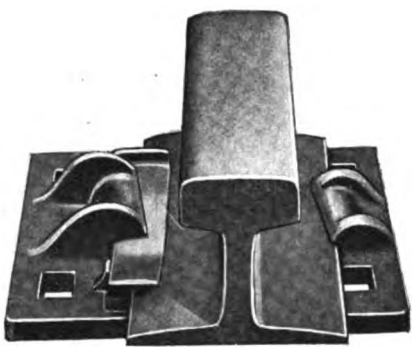


Positive Anti-Creeper
The Positive Rail Anchor Co.

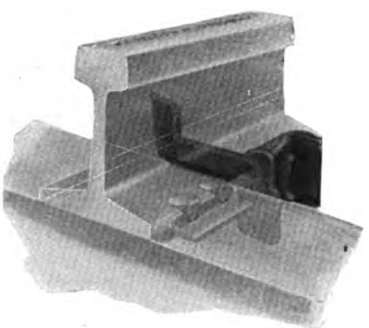
Henggi Anti-Creeper
The P & M Co.
(See Page 771)



Thomas Anti-Creeper Tie Plate
The Chicago Malleable Castings Co.
(See Page 663)



Trasco Anti-Creeper
The Track Specialties Co.
(See Page 817)



Vaughn Anti-Creeper
The P & M Co.
(See Page 771)

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They must be easy to apply under full-ballasted track.

They must be substantial enough to stand driving to place without chance of breaking.

The least possible number of movable parts is desirable.

When applied they must be in position rigidly enough to carry the tie with them in any kind of ballast without slipping.

They shall be made with sufficient take-up to permit of proper tightening.

When in place they must not loosen sufficiently to render them inoperative when the rail slacks back.

Controlling or delicate parts should be made of non-rustable material.

Anti-creepers made of steel shall be of sufficient size to minimize their destruction by rust.

Anti-creepers made of malleable iron must be from furnace malleable iron properly annealed, and of sufficient weight to prevent breakage and distortion in application or in service.

ANTI-CREEPER CLIP (Frog). See Anti-Creeper Lug (Frog).

ANTI-CREEPER LINK (Frog). A steel strap or bar sometimes used to anchor the spring wing of a spring rail frog to the frog plate, or parts of slip switches to the ties or substructure to prevent creeping. See Frog, Spring Wing Rail.

ANTI-CREEPER LUG (Frog). A small forging used to fasten the anti-creeper strap to the wing rail of a spring rail frog.

Anti-creeper clips are variously formed. A common shape is an angle plate the vertical leg of which is bolted to the web of the wing rail and the horizontal member fastened to one end of the anti-creeper.

ANTI-CREEPER STRAP (Slip Switch). A flat steel bar or similar device designed to be fastened to a tie or ties at one end and to one of the middle rails of a switch at the other end, with a view to preventing the rails from creeping.

One style of anti-creeper strap is approximately 4 ft. 6 in. long, the outside end fitting edge-wise against the inside joint bar at the heel of the end-point rail and being held in place by the heel block bolts; while a 90 deg. twist at the middle of the strap permits the inside end to be spiked to two adjacent ties near the center points. There are two pairs of anti-creeper straps on a double slip switch, one attached to each end of each of the two middle rails to prevent creeping in either direction.

ANVIL FACED. Provided with wearing surfaces of abrasion-resisting metal, such as ferro-manganese steel. This term is commonly used in connection with track devices. See Frog. Also Switch.

ANVIL FACED HEEL RISER BLOCK. A heel riser block faced on the top surface with some especially hard metal. See Heel Riser Block (Frog).

AUGER, POST HOLE. A tool for boring holes in soil for posts, etc.

A type of post hole auger in general use is made of a spiral steel bit or cutting piece attached to the bottom end of a round iron rod or pipe which terminates in a "T" to hold a cross handle. The bit consists of two thin, sharpened, slightly twisted, semi-circular steel blades, fastened by iron straps about 3 in. above the point of the bore. The shank or rod is usually an iron pipe about 1¼ in. in diameter and about 3 ft. long, threaded on the end to fit the "T" connection holding the handle, allowing for adjustment of additional short lengths of pipe. The auger is screwed into the ground by twisting the horizontal wooden handle while pressing the tool down vertically.

Post Hole Auger

Post Hole Digger (Spud)

AUGER, POST HOLE (Spud). A straight round steel bar with a long narrow wedge-shaped working end, designed to loosen hard ground. The tool is usually 5 ft. 6 in. long over all, the bar being 1 in. in diameter and the blade about 3 in. wide and 12 in. long. Some such bars have tamping heads, while others have ring handles. See Fence.

B

BALLAST. A selected material in which the ties are embedded to stabilize the track structure on the road bed, hold it in line and surface and distribute the wheel loads onto the road bed. Ballast preferably consists of hard particles that can be handled readily with shovels, and tamped under and filled in between the ties and about their ends so as to transmit the loads readily to the road bed, while at the same time affording drainage for water. The particles should be of such weights, shapes and relative sizes that the ballast will not be displaced nor eroded readily, nor cut into the fibre of wooden ties. Ballast should be non-absorbent, clean of dust and retardent to plant growth. Crushed stone, gravel, burnt clay, slag, cinders and sand are the materials in most common use.

In the early days of railway construction, earth was commonly used for surfacing, especially in prairie localities such as the middle western states, where harder and more suitable materials were not readily

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obtainable. Although it will hold track in line and surface temporarily, earth is not as good as ballast, for in dry weather it is dusty, while in wet weather it becomes muddy, even when sloped sharply to shed water; at no time is it firm enough to afford the best foundation, while it tends to attract plant life and moisture and so hasten decay in the ties. These objections led early railway builders to search for more suitable materials.

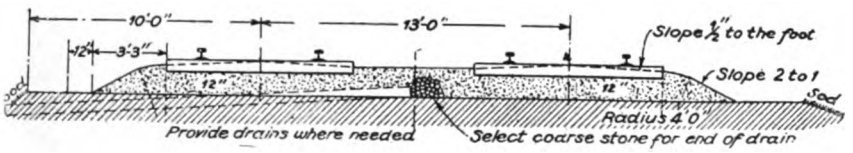
In localities where natural deposits of gravel and stone existed, search was made for deposits of these materials, preferably on or near railway land, in order to minimize real estate purchase and the lengths of tracks necessary to reach the pits or quarries. Where no such natural deposits were obtainable, in some instances clay or gumbo was burnt in improvised kilns and broken to suitable sizes. This material, however, unless it is entirely free from sand, tends to crumble and disintegrate in time, especially from the action of frost. Cinders are generally in demand, but are usually limited in distribution to the regions of locomotive terminals and to light traffic branch lines and switching yards. Cinder ballast lies close, retards the growth of grass and does not mingle with the clay or earth of the road bed; but is too light, porous and easily powdered to endure as top ballast under heavy traffic.

The best materials have been found among the many varieties of gravel and stone, which admit of various treatments such as crushing, screening, washing and grading to sizes most suitable for stabilizing the track structure. Stone is generally crushed and screened, but many railways own gravel pits in which almost any combination of earth, sand, pebbles and boulders may be found in glacial beds. These mixtures are commonly used as pit run gravel with no treatment other than the wasting of an occasional carload of clay, stripping or boulders. So much earth and fine sand commonly finds its way into the track structure as pit run gravel that many road beds are dusty when dry, miry when wet and heavy in frosty weather. The expense and futility of efforts to maintain tracks effectively on inferior ballast are responsible for the growing tendency toward the selection of clean ballast composed of particles which drain well and form a firm bed for the ties.

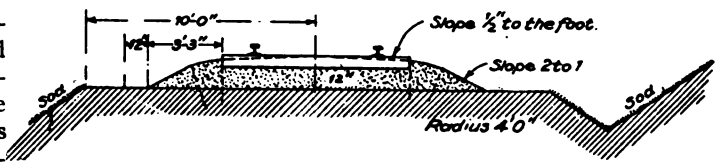
Owing to accumulations of coal or other materials which fall from passing cars or of ashes from locomotive fire boxes, of dust from the road bed and other debris which falls on the surface, as well as earth which works up from below, the renewal or reclamation of ballast is necessary to maintain drainage. Pit run gravel and inferior materials are commonly renewed by raising the track and adding a new layer of top ballast. Crushed stone or crushed gravel is more frequently removed, screened and replaced at intervals of five years or less, according to local necessity. The material is commonly removed with hand shovels, handled onto the screens by means of shovels or ballast forks and replaced with forks. Self-propelling power machines equipped with ballast scoops, shaking or inclined screens and conveyors are also coming into use for this purpose.

Holding the track in line and surface is a function which involves all the more important demands made on ballast. Drainage is necessary to insure a firm foundation, without which the ballast will sink into the road bed beneath the rolling loads. The requisite drainage can only be had with a ballast composed of hard particles with spaces between which permit the water to percolate rapidly and run off the road bed. Line and surface depend also on having a sufficient body of ballast to distribute properly the loads on the track to the road bed, and to embed the entire lengths of the ties. The depth of ballast needed depends on the wheel loads, on the character of the material and on climatic conditions, etc.

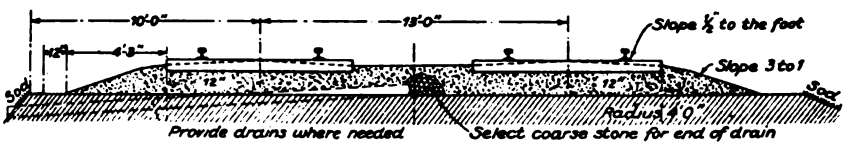
The minimum depths of ballast recommended with the best drainage conditions are 12 in. under the ties for class A tracks, 9 in. for class B tracks and 6 in. for class C tracks. Since perfect drainage conditions are not uniformly attainable on any class of line and are seldom approximated except on some parts



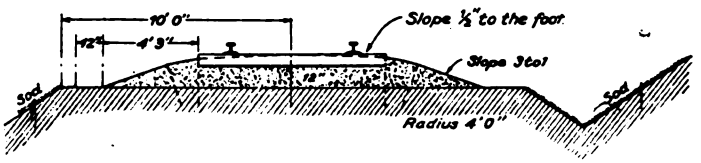
A. R. E. A. Standard Crushed Stone and Slag Ballast Section for Class A Double Track



A. R. E. A. Standard Gravel, Cinders and Chats Ballast Section for Class A Single Track



A. R. E. A. Standard Gravel, Cinders and Chats Ballast Section for Class A Double Track



A. R. E. A. Standard Gravel, Cinders and Chats Ballast Section for Class A Single Track

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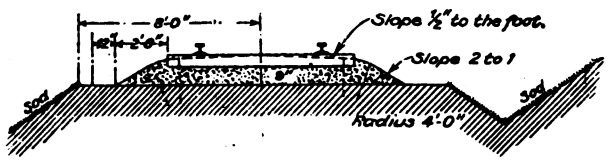
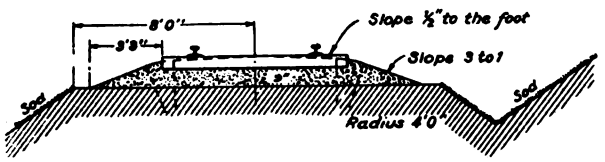
of class A lines, more than these minimum depths of ballast would seem advisable in practice, in the interest of ultimate economy and maintenance efficiency. Ballast sections in general are crowned at the track center, declining slightly and symmetrically to the rails or to the ends of the ties, where the slopes are increased or curved downward over the shoulder to the road bed. The slopes depend on the character of the ballast to be drained and the amount of material necessary at the ends of the ties to hold them in line. The earth surfaced section usually covers the ties in the center of the track to a depth of about 3 in. and slopes down so that the water can escape beneath the rail bases. Hard ballast sections commonly slope ½ in. to the foot from the level of the top of the tie at the center line of track to points near the rail where the slope increases to one foot in two or three feet, to the road bed. Although the surface of the ballast is readily maintained the bottom line of the cross section is of greater importance for if it is concave, perfect drainage is not possible.

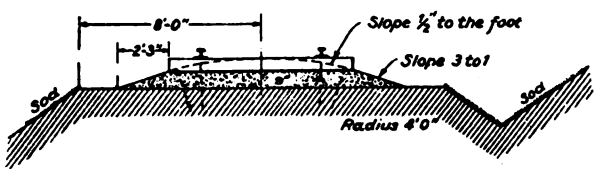
Ballast is conveniently loaded in hopper-bottom or side dump cars at pits by means of steam shovels or directly from crushers and is distributed along the track as needed; or it is loaded on flat cars and plowed off with a ballast plow pulled by a cable winding on the drum of a power-driven machine called a ballast unloader, which is mounted on a car carried with the ballast train. The ballast is commonly spread down to the level of the top of rail level with a special plow called a spreader. The



A. R. E. A. Standard Crushed Stone and Slag Ballast Section for Class B Track



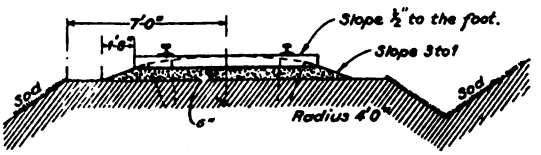
A. R. E. A. Standard Gravel, Cinders and Chats Ballast Section for Class B Track



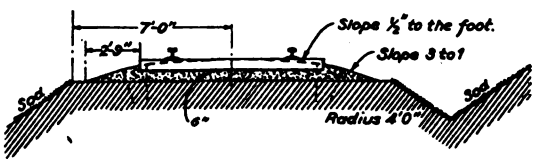
A. R. E. A. Standard Gravel, Cinders and Chats Ballast Section for Class B Track

material is then placed in the track by hand and tamped with picks, shovels, bars or power-driven tools.

In ballasting newly-laid tracks, care should be taken to have the road bed fully graded to prevent waste of the ballast material, for earth is usually much cheaper and more easily obtained than hard ballast. If the slopes of the embankments are slack or the road bed is narrow there is a tendency for the ballast to roll down the slopes when being unloaded from cars; while if the road bed is low on top, an extra depth of ballast is required to bring the track to the approved grade line. It is advisable if possible therefore to delay the full ballasting of track on new earth road bed until the initial subsidence following a few rainfalls has developed the low spots which can then be refilled first with earth or refuse from the ballast pit. Such temporary ballasting as is needed beneath the rail bearings to keep



A. R. E. A. Standard Cementing Gravel and Chert Ballast Section for Class C Track



A. R. E. A. Standard Cementing Gravel and Chert Ballast Section for Class C Track

the newly laid track in fair surface for the light traffic of construction is commonly done with sand or earth, care being taken meantime to restrict train speeds in order to avoid bending the rails and injuring the fastenings.

When permanent ballast is distributed the track is raised on jacks and the material is shoveled and tamped under the ties. It is usual to lift track not to exceed 6 in. in one operation unless the total depth of ballast needed is 10 in. or less when it is frequently all placed at once to avoid making a second light lift which is a difficult operation, especially with large crushed rock. The second lift of 6 in. or more, if any, is commonly made in a second operation. The top ballast, which is filled in between the ties and on the shoulders, is usually of the smaller particles, the larger having been used for bottom ballast, for drains between tracks, for borders of hand car take-offs, etc. The super-elevation of curved track is commonly effected by inclining the surface of the ballast section toward the outside shoulder.

It is usual in placing ballast to raise the track according to the heights and line of stakes set in the road bed, the track lift being obtained with a level and spot board and the operator sighting from one stake to another over track lengths of 50 ft. to 100 ft. Track is roughly lined to the stakes before ballast is distributed to avoid the heavier work of throwing it with this material between the ties. After such preliminary throw the final lining is commonly a matter of only an inch or two, after the ballasting is completed. Dust which settles in the ballast is frequently minimized in the vicinity of cities by the application of crude oil which is sprayed on the ballast, usually from special sprinkler-equipped cars, which are run over the tracks two or three times during the dryest season of the year. See Ballast, Crushed Stone. Also Ballast, Gravel. Also Ballast,

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Cinder. Also Ballast, Chats. Also Ballast, Cherts. Also Ballast, Burnt Clay.

Instructions to Govern Ballasting on an Operated Line. (A. R. E. A.)

Authority. Decision of the kind and amount of ballast to be applied having been made by the proper officials, the work should be handled as follows:

Plans. The division engineer or roadmaster, whichever is to have responsible charge, shall lay his plans for work train movements and service before the trainmaster and chief dispatcher, in order that they may have a clear understanding of what is desired to be done, and that they may be able to assist the movements to be made with as little delay as possible.

Ballast Supply. If the ballast is to be furnished by the company or from a pit for which the company is responsible, a careful inspection of the pit tracks and appurtenances shall be made and everything put into serviceable condition.

Equipment. All equipment, such as steam shovel, mechanical unloader, unloading plows, material spreader, ballast plow, or spreader, etc., shall be gone over and put into working order.

Protection. Speed restrictions shall be arranged for in accordance with operating rules before the track is disturbed, and shall be maintained until the track is in safe condition for schedule speed.

Preparation of Road Bed. Preparatory to placing ballast, the road bed shall be widened, if necessary, to bring it to the A. R. E. A. standard width, by dumping material alongside of the track and spreading it to the required width and slope, preferably by the use of a material spreader. Where necessary to raise the road bed level, porous material must be used to avoid the forming of water pockets by burying in of old ballast.

All bank widening shall be done far enough in advance of the ballasting work so that there will be no interference between work trains or gangs.

Skeletonizing. After the banks have been widened, and not to exceed two days' work ahead of where new ballast is being dumped, the track shall be skeletonized. Where the material is suitable for sub-ballast and the grade will permit, the track shall be raised and the old material spread under and between the ties, and to the proper width, as uniformly as is practicable.

Where conditions do not permit of raising the track, the old material shall be removed to the required depth and disposed of as directed.

Where not suitable for sub-ballast, the old material shall be removed to the plane of the bottom of the ties, or deeper if necessary to preserve the grade line and shall be placed on the outer shoulder of the road bed, preferably at such points as will tend to even up the line of the shoulder.

Use of Jacks. In using jacks, they must be placed close enough together to prevent undue bending of the rail or over-strain of the joints. Where the road bed material is heavy or holds to the ties tenaciously, it is sometimes necessary to place three or more jacks per rail length. Jacks should be worked in pairs directly opposite each other, and a sufficient number should be used simultaneously, so that no jack will raise the rail more than four inches above its level at the next succeeding jack or place of support.

Tie Renewals. Following the skeletonizing of the track, the tie renewal gang shall take out all old ties which are not fit for more than one year in track, where gravel or cinder ballast is to be used; or for more than three years in track, where stone or hard slag is to be used; and insert new ties in their places. All ties must be properly straightened and spaced.

The track must be fully regaged as the new ties are being spiked up. Old ties must be disposed of as directed.

Grade Stakes. Ballast grade stakes shall preferably be set after the bank widening, skeletonizing and re-tieing have been done, and before the ballast material has been dumped and spread. This is desirable to avoid, as far as possible, interference with the stakes, yet to have them available as a guide for the unloading of ballast.

Drains. All tile, box or other drains required to take care of water from between tracks shall be placed before the ballast material is unloaded.

Unloading of Ballast. Ballast shall be unloaded by dumping or plowing, as the means provided permit. If the ballast be in center dump cars, it shall be unloaded by having one or more cars opened a little at a time and allowing the required or desired amount of ballast material to flow out as the train is slowly moved along. If the material be on flat or open-side cars, it shall be plowed off by means of an unloading machine while the train is standing or moving at such a rate of speed as to provide the desired amount of material as uniformly distributed as possible. The unloaded material shall be leveled down by means of a ballast plow, or of a spreader, consisting of a heavy timber with wheel skids attached to it, and placed in front of the leading pair of wheels of the rear truck. Care must be taken not to destroy or disturb the grade stakes.

Parallel Tracks. Where a new track is being built parallel to an existing track, ballast material can be advantageously handled in body dump cars which dump the entire load to the side desired, after which the ballast material may be spread to the required width and depth by the use of a material spreader, and the track laid after the ballast is in place.

Preliminary Surfacing. The first lift shall be a filling lift. The filling, or preliminary surfacing gang, shall follow the unloading as closely as the regularity of the ballast supply will permit. The amount which the track should be raised at one lift will depend upon the depth of ballast to be applied. Usually, track should not be raised more than 6 in. at a lift, but if the total lift of the track is to be more than 10 in., a first lift of 7 in. to 8 in. may be made if traffic conditions will permit, leaving the remainder of the raise for the finishing lift. A sufficient number of jacks must be used simultaneously to avoid damage to rails. The raise on any one jack shall not be greater than 4 in. above the next jack, or point of support. Both rails must be raised at one time, and as nearly uniformly as is practicable.

The filling lift shall be made by jacking the track up to the required height, and the ballast material then forked or shoveled in and worked to as uniform a surface as possible by the use of spades. It shall then be left to be compacted by traffic, but a small lookout gang shall go over it after a few trains have passed, and pick up any spots that show too great an inequality of settlement.

After a few days, depending upon the amount of traffic over the track, another lift shall be made—either another filling lift or a finishing lift, according to the depth to which the track is to be ballasted. If another filling lift, it shall be made in the same manner as the first one.

Finishing Lift. When the track has been raised to within 2 in. or 3 in. of the final grade and properly compacted, a finishing lift shall be made by jacking up the track to the exact height provided for by the grade stakes (all allowance for settlement shall be taken care of in the setting of the stakes) and the necessary ballast forked or shoveled in and then driven to place by the tamping machines, tamping picks or bars, if rock or heavy ballast is used. Shovel tamping should be used with gumbo, cinder or light sandy gravel ballast. In making the finishing lift, the spot board and level board must be used with care, and the track brought to as true a surface as possible.

Alinement. The track shall be placed in good alinement before the finishing lift is made, but a lining gang shall follow one or two days' work behind the finishing lift and shall spot up all places found not to be holding up to proper surface and shall line the track to as accurate alinement as possible.

Center stakes shall be set for the alinement before the finishing lift is made, and the final alinement must conform to the center stakes.

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Dressing. Following as closely as possible behind the lining gang, the dress-up gang shall finish the work by filling the track center to the required fullness and then dressing it toward the toe of ballast, preserving the proper clearance under the rail and proper curve and slope of the shoulder. The toe of ballast shall be made a true line, parallel to the center line of track, and any surplus material shall be raked far enough from the toe line to permit of being forked or shoveled up without fouling or disturbing the finished ballast.

No ballast material or refuse out of ballast or road bed material which would interfere with a mowing machine when cutting grass and weeds shall be cast off of the road bed or be left where it will interfere with the use of mowing machines or scythes.

Clean-Up. When the dress-up gang leaves any part of the track as completed, it shall be in first-class line and surface. The ballast shall conform to the ballast sections as adopted by the A. R. E. A. All surplus ballast shall have been loaded, and all refuse and rubbish shall have been removed, loaded or destroyed, so as to leave the right-of-way and shoulders of the road bed in condition to be mowed without interference.

BALLAST, BURNT CLAY. Heavy, plastic clay free from grit, which will not crumble on contact with the air after thorough burning in a pit or kiln.

Suitable ballast clay is found in quantity in the middle western states where it is principally used

Burnt Clay Ballast

under tracks carrying medium traffic. Samples are first burnt to test the clay, which is preferably prepared in pits on sloping ground which is not subject to floods. A deep deposit of uniform clay and a convenient water supply are desirable. The fuel used is preferably slack coal, which should be continuously fired between alternate layers of clay. A new layer of slack 1 in. to 1½ in. thick and a layer of clay 10 in. to 12 in. thick should be added to the pit at intervals of five to six days.

The burnt ballast should be bright red and non-absorbent, as an absorbent ballast will crumble from the effects of frost action in winter. After burning it is broken to pass a 4 in. ring, the top ballast being somewhat smaller. It is clean, fairly easy to handle and drains well, but will crumble in time under heavy traffic, especially if affected by the action of frost.

SPECIFICATIONS FOR BURNT CLAY BALLAST.
(A. R. E. A.)

1. **Kind of Material.** Good ballast clay is heavy and plastic, free from sand, gypsum or other impurities. It must not crumble when exposed to air or when brought in contact with heat.

2. **Location.** The pit should be located on level or moderately sloping ground not subject to overflow. A water supply is desirable and it should be borne in mind that the sulphurous and carbonaceous gases liberated during the burning period damage the surrounding vegetation and make habitation in the near vicinity very disagreeable.

3. **Test.** The location site should be thoroughly tested to determine the quality of the clay, the depth and uniform consistency of the deposit, and small quantities should be burned in test kilns to show the quality of the ballast to be secured.

4. **Burning.** Fuel should be fresh, clean slack, and arrangements should be made to secure constant supply. One ton of slack coal is generally sufficient for the perfect burning of four cubic yards of acceptable ballast. From one to one and one-half-inch layer of slack is alternated with from ten to twelve-inch layer of clay, a new layer of slack and clay being applied to the fire every five or six days.

Fires once started must be kept steadily and uniformly burning.

To insure thorough and proper burning of the clay, the top and face of the fire should be frequently raked down, to avoid clinker or black spots, caused by too much or too little air.

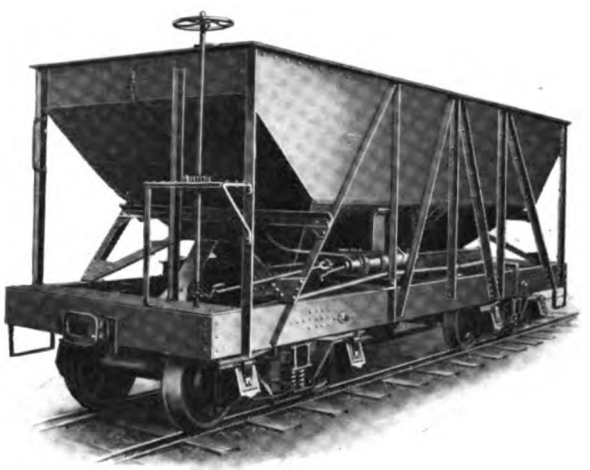
When fully burnt a proper ballast clay becomes red in color, when the clay contains iron; when under-burnt the clay will show a yellow color.

5. **Size.** Burnt clay ballast should be crushed or broken, if necessary, so that the largest piece will pass through a 4-inch ring.

6. **Density.** The finished product should absorb not to exceed 15 per cent. of moisture by weight.

BALLAST CAR. A car suitable for loading, transporting and unloading ballast on the road bed. The most economical ballast equipment is that which has the widest range of uses for company and commercial purposes.

Flat cars are frequently converted for use in ballast service by fitting them with side boards and with hinged sheet iron aprons which bridge the



Hopper Bottom Ballast Car
The Kilbourne & Jacobs Manufacturing Co.

spaces between cars and complete the continuous deck over which the unloader pulls the plow to sweep the load from the train and which may be folded up on the car when not in use. An advantage of the flat car as a ballast car is its general utility,

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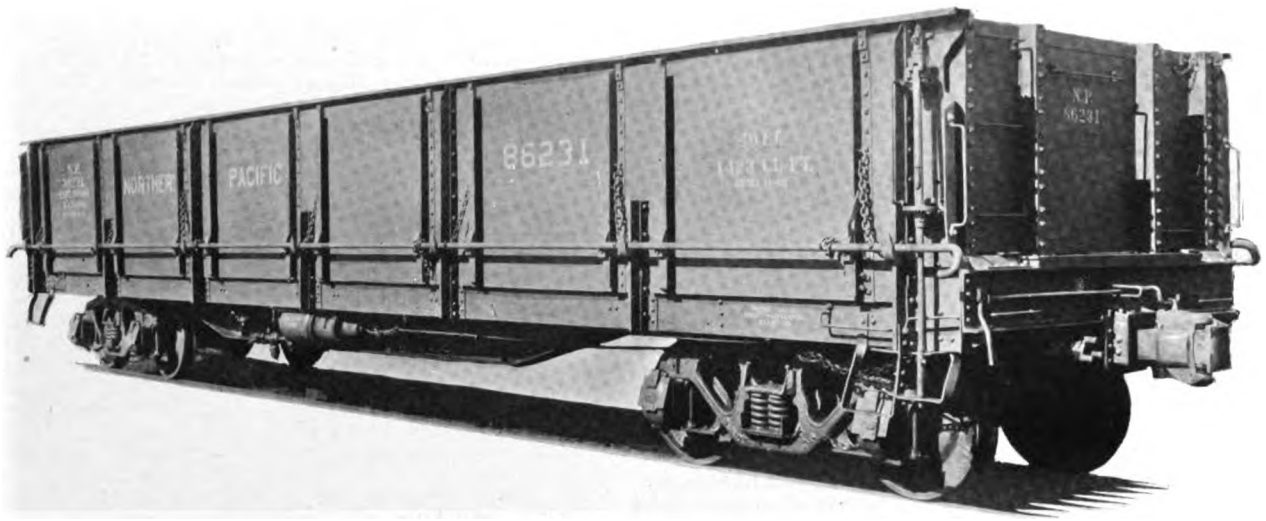
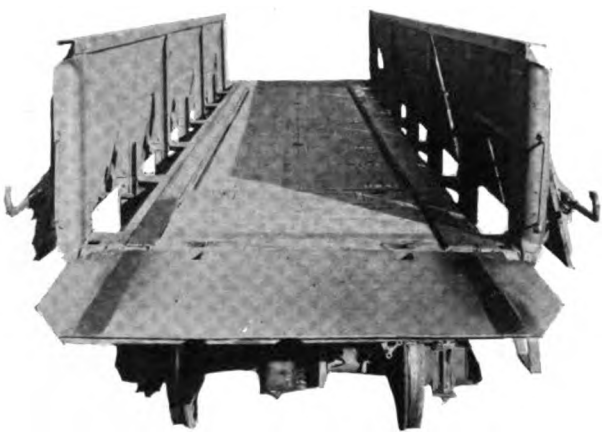
but its capacity is limited to one-third or at the most one-half that of the gondola. The work of equipping flats with aprons and side boards is considerable and the assembly of the cars and special parts is a matter involving time and expense.

an endless apron ballast car with top hinged sides that swing out and up from the floor line when the load is to be plowed off.

Side dump cars of the larger patterns holding 20 to 35 cu. yds. of ballast and equipped with the neces-



Convertible Ballast Car—Gondola
The Rodger Ballast Car Co.
(See Page 798)



Convertible Ballast Car—Side Dump
The Rodger Ballast Car Co.
(See Page 798)

Special ballast cars are usually of the hopper bottom or side dump type, designed to unload automatically. The hopper bottom ballast car has a body, the whole or lower portion of which is composed of plane surfaces which slope down and in at angles too sharp to retain the load when the hopper is opened. Ordinarily the movable side walls of the hopper are hinged at the top and converge to a trough shape, being held in that position by chains which pass under the hopper and are wound on revolving shafts to close it or are released and unwound to allow the sides to fall apart and discharge the load by gravity. The shafts are usually operated by means of gears or ratchets which engage levers, attached to the outside of the car at the ends. The discharging devices are usually arranged so that one-fourth, one-half, or all the contents of the car may be dumped in a single operation.

The convertible ballast car is adaptable to a variety of uses. It may be changed from a gondola to a side dump or a center dump ballast car, or used as

Convertible Ballast Car—Center Dump
The Rodger Ballast Car Co.
(See Page 799)

sary safety devices and air brakes are frequently used in regular trains as ballast equipment. These cars are usually dumped by compressed air power, one side dropping and extending as an apron to convey the ballast away from the track when the body is tilted; or a system of levers attached at the ends of the car automatically holds up the side clear of the contents while it is being discharged from the inclined floor. See Dump Car.

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BALLAST, CHATS. Finely crushed rock tailings from zinc and other ore mines, sometimes used as ballast. This material, known also as stamp sand, consists largely of heavy particles of uniform size, the dust and finer sand being eliminated by the water used to force the tailings down sloping flumes or launders from the mine to the waste pile. As ballast this material works easily and drains well when clean, but will not endure as well as crushed rock of larger particles.

BALLAST, CHERT. An impure flint or hornstone occurring in natural deposits. (A. R. E. A.)

This material ranks as a crushed rock ballast, but is frequently found in drifts as well as in strata. In the former case it usually is mixed with clay which serves as a binder, but causes churning of the ballast when saturated. Chert breaks with sharp cutting edges, holds in place better than gravel and drains well when clean. It is found in quantities in some of the southern states.

BALLAST, CINDER. The residue from coal burned in locomotive and other furnaces. Bituminous coal cinder is desirable as ballast chiefly for light traffic tracks, or in soft clay or swampy bottom as a sub-ballast, since it will not mingle with nor sink into wet clay nor break through the surface of a swamp as heavier ballast does. It absorbs water and holds frost, but effectually retards the growth of grass and weeds. As a top ballast it tends to crumble and become dusty with age. It is available generally on steam railways and is commonly loaded into cars direct from the ash pits at locomotive terminals, its only cost being that of transportation and putting under the tracks, as it must be unloaded whether used for ballast or wasted. The A. R. E. A. recommends the use of cinder ballast on branch lines

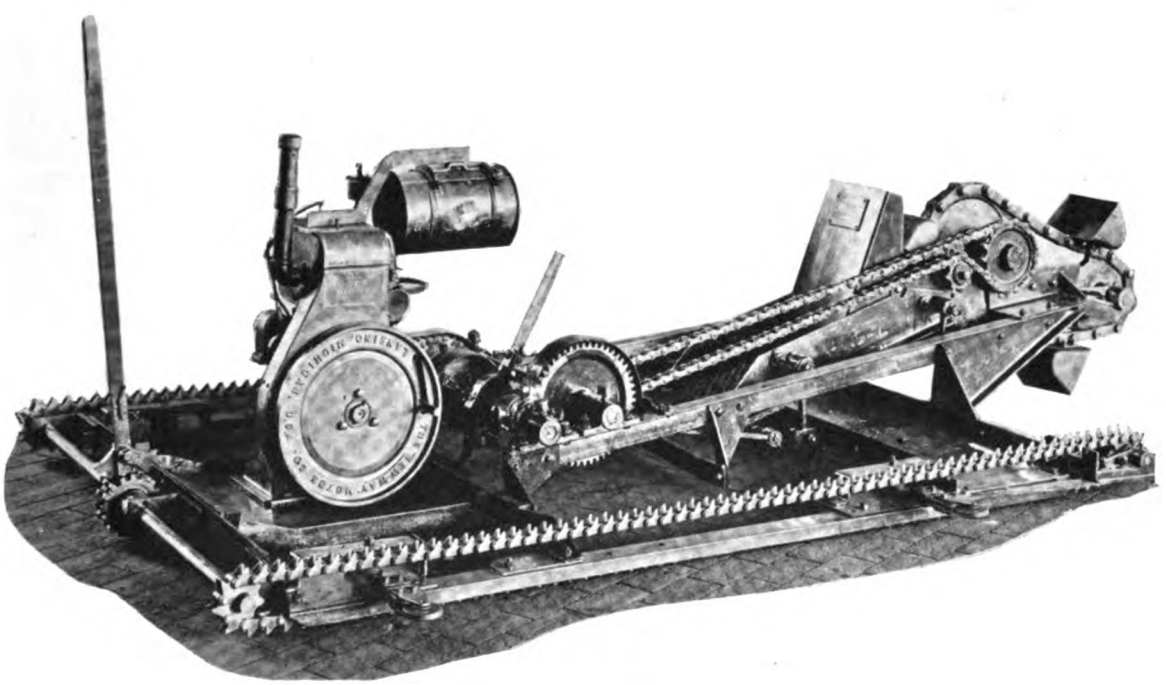
Typical Cinder Ballasted Track

carrying light traffic, on sidings and yard tracks, and as sub-ballast on soft bottom or settling road beds.

BALLAST CLEANER. Any screening device by which the dirt or other foreign matter is removed from the ballast.

Crushed stone ballast is screened periodically on many railways, while cheaper ballast materials such as gravel or cinders are usually covered with a top layer of new ballast. Lines transporting heavy tonnages of coal, ore, etc., in hopper bottom cars find it necessary to clean crushed stone ballast at comparatively short intervals, sometimes as often as two or three years, whereas the average interval on lines not carrying such special freight is approximately five years.

The cleaning is frequently done by removing the ballast and handling it on forks with a view to freeing it from dirt which falls between the tines of the forks that hold the coarser ballast. Preferably



Pratt Ballast Cleaner
The Link Belt Company

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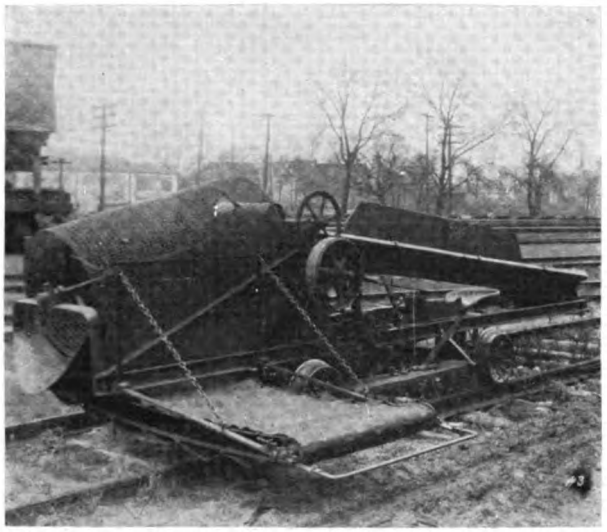
the stone is thrown from the forks onto inclined screens down which it rolls and is separated more effectively from the dirt, or it is scooped or conveyed



Harris-Muff Ballast Screen
The Maintenance Equipment Co.
(See Page 739)

by power to the screens of portable cleaning machines. Sometimes a car fitted with adjustable toothed rakes on each side is used to stir up the top ballast on the shoulders outside the ends of the ties.

BALLAST CRUSHER. A machine designed to crush or re-crush stone and boulders to sizes suitable for ballasting tracks. Extensive rock crushing plants commonly have large crushers for producing 4 in. to 6 in. stone from large rock or boulders, and smaller machines to re-crush this material to particles ranging from 1¼ in. to 2½ in. in size suitable for ballast. See Rock Crusher (General Section).

BALLAST, DISINTEGRATED ROCK. A natural deposit of fragmentary rock, usually granite, but sometimes a quartz formation which is quarried and used as ballast in a few localities on some American and foreign railways. It breaks in pieces convenient for ballast when blasted to loosen it from its bed or is easily broken along lines of natural cleavage to the proper sizes. The particles are hard, heavy, inert and difficult to handle as ballast, but pack, drain and hold track well.

BALLAST FORK. A tool similar to a spading fork, but with a wider spread of more and longer tines, designed for handling crushed stone and for cleaning crushed stone ballast of dirt accumulated

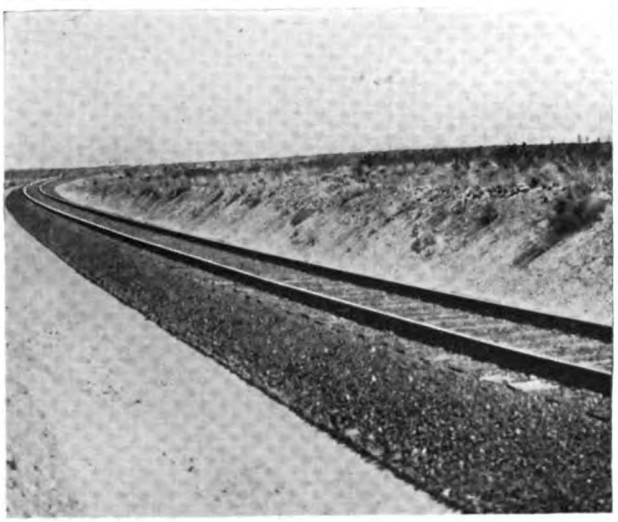
Ballast Fork

while in use in the track. This tool is about 3 ft. 6 in. long over all with a wooden D handle, and with 10 to 14 tempered steel tines usually 13½ in. long, which are square in section, tapering toward the free end and attached to a steel shoulder which curves upward at each side to retain the bulk of the load on the tines close to the handle, which is riveted to the fork in a long strap ferrule. The spaces between the tines, limited to suit the ballast, are usually about 1 in. to 1⅛ in. wide.

BALLAST, GRAVEL. Worn fragments of rock, (occurring in natural deposits) that will pass through a 2½ in. ring and be retained on a No. 10 screen. (A. R. E. A.)

This ballast is valued above all kinds except crushed rock. It is usually composed of hard particles worn smooth and round by glacial pressure, being inferior to rock only because its rounded pebbles do not bind together so readily as the sharp edge stone.

Gravel is the most readily available and widely used of all ballast materials. It occurs in extensive



Typical Gravel Ballasted Track

glacial beds, sometimes in high ridges several miles in length, but often in smaller bodies underlying level ground. It exists commonly in strata alternating with layers of sand and boulders with which materials it is usually more or less mixed. Desirable pit-run gravel ballast is free from clay and loam, but may contain from 25 per cent to 50 per cent of clean sand, mixed with gravel particles which will pass a 2½ in. ring. Coarser particles and boulders are less objectionable than an excess of sand or the presence of clay or loam, for boulders may be sorted out, thrown aside or crushed for ballast or for other maintenance purposes. Desirable gravel ballast pits are those which are convenient to the tracks to be ballasted, easily drained, of sufficient depth to enable the material to be loaded by steam shovel or similar equipment and of sufficient area to warrant the installation of adequate storage, passing and repair tracks of suitable alinement, as well as room for the disposal of stripping and boulders. For economical exavation by steam shovel the material should lie close to the surface in level strata not less than 6 ft. deep.

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Gravel pits are commonly tested by sinking suitable shafts or test pits from which samples of about 1 cu. ft. are obtained at various depths and portions of the pit area. After testing the separate samples by screening the dust and other ingredients from the gravel and measuring their percentages of the whole volume, the samples are thoroughly mixed and a final test of the aggregate is made to obtain the average run of the pit.

Where gravel is mixed with large boulders it is frequently graded to size in either portable or stationary screening plants. Portable plants usually have elevated inclined rotary screens of tubular sheet iron, perforated with holes of suitable diameter which receive, sort and deliver the material from a conveyor consisting of an endless chain or belt, carrying the material on the belt, or in pockets which dump it automatically into the upper end of the revolving screen as the belt rotates about a horizontal return roller at the top end of the frame. Thence the material is rotated in the inclined screen, the small particles dropping through the holes, while the larger gravel passes by gravity to the lower open end of the screen and thence to the loading chute. The larger stationary plants have various kinds of screens, usually of the elevated, inclined, fixed or rotary types.

To cleanse the ballast of earth and fine sand, washeries are sometimes installed. Usually such a plant is constructed on the gravity plan, the gravel being dumped from cars into a hopper from which a pan or other conveyor takes it up a 30 deg. incline to a receiving hopper 40 ft. to 50 ft. above the receiving tracks. Jets of water play on the gravel as it falls from the screen into an inclined chute, washing the particles as they separate into bins or pockets suitably located below the screens to receive certain sized pebbles, which are stored there until they are loaded into cars below through doors in the bottoms of the bins; the muddy water running away through a flume after leaving the gravel. The plant is commonly operated from a stationary power plant erected for the purpose close to the screen house.

Boulders and coarse gravel are frequently broken in a rock crusher erected and operated in conjunction with a washing and screening plant. Boulders found in gravel beds are usually hard, dense stones that have resisted the crushing action of glaciers and, when broken to proper sizes, make excellent and enduring ballast, resembling crushed stone but possessing the advantage of a considerable percentage of curved surfaces which render the ballast more easily worked with less of the tendency to injure the fibre of wooden ties than the sharper edged rock ballast.

SPECIFICATIONS FOR GRAVEL BALLAST. (A. R. E. A.)

For Class A railways: Bank gravel, which contains more than 2 per cent. dust or 40 per cent. sand, should be washed or screened. Washed or screened gravel should contain not less than 25 per cent. nor more than 35 per cent. sand.

For Class B railways: Bank gravel, which contains more than 3 per cent dust or 60 per cent sand, should be screened or washed. Washed or screened gravel should not contain less than 25 per cent nor more than 50 per cent sand.

For Class C railways: Any material which makes better track than the natural roadbed may be economically used.

BALLAST PICK. A combined prying and ramming tool designed for loosening and compacting particles of ballast around and beneath the ties of a railway track and consisting of a slightly curved bar

A Tamping Pick for Use in Coarse Ballast
(See Pages 706, 829 and 832)

of iron about two feet long tipped with steel and furnished with an eye or other fastening at the middle to receive a handle or helve. One end of the bar is pointed for prying ballast loose while the other is a blunt pounding end with a rectangular face

A Tamping Pick for Use in Fine Ballast
(See Pages 706, 829 and 832)

about ½ in. to ¾ in. thick, and 2 in. to 3½ in. across, the longer dimension being at right angles to the axis of the bar. The working ends of ballast picks are subjected to such severe service that picks are now being made in some instances with working ends of steel of special treatment or composition with a view to increasing the life of the tool.

BALLAST PLOW. A machine designed to be pulled over flat or convertible cars to unload ballast by scraping and pushing it from the sides and distributing it along the track. It may have one or two congerging faces arranged diagonally to the direction

Bucyrus Center Plow
The Bucyrus Company

of pull. The center plow is V shaped with both faces plowing surfaces and set at equal angles to the medial line of the device, their spread being about equal to the width of a car, the nose of the plow moving along the center line of the car to part the ballast so that half of it falls to either side as the diagonal faces force it outward. Right hand and left hand side plows are designed to unload ballast on one side of the cars. The side plow is built so

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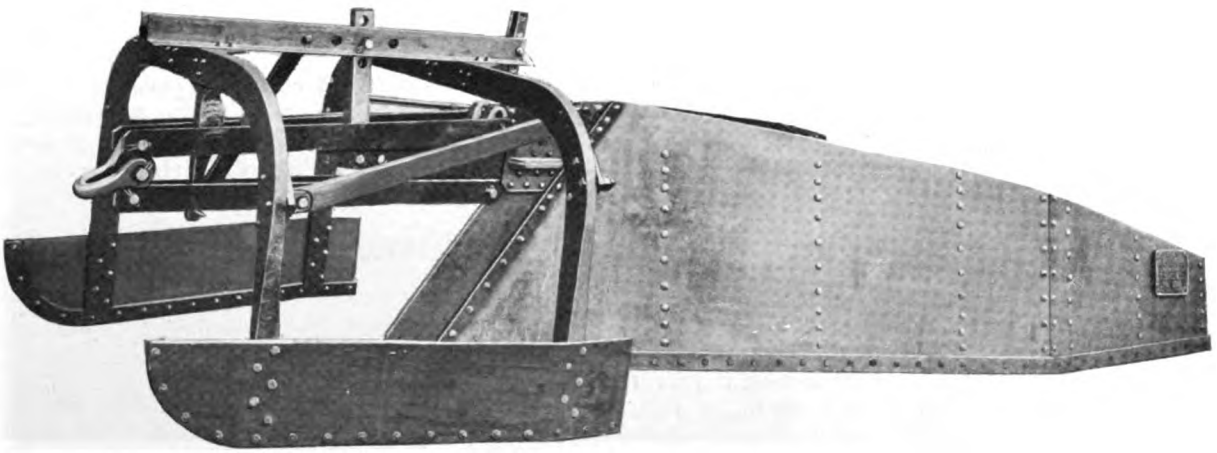
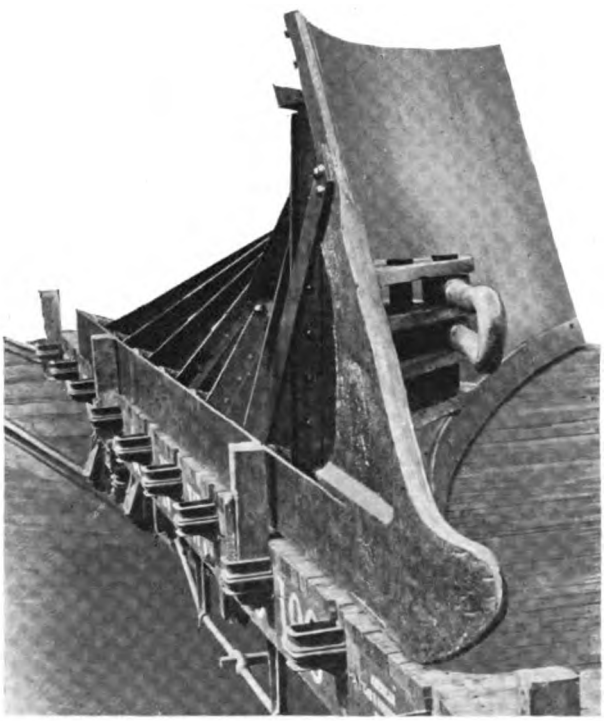
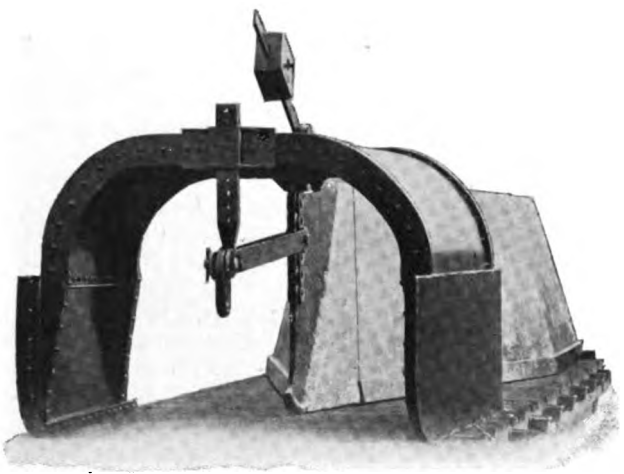


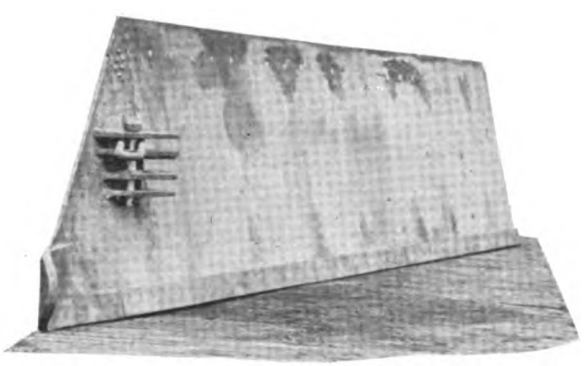
Center Plow
The Bucyrus Company



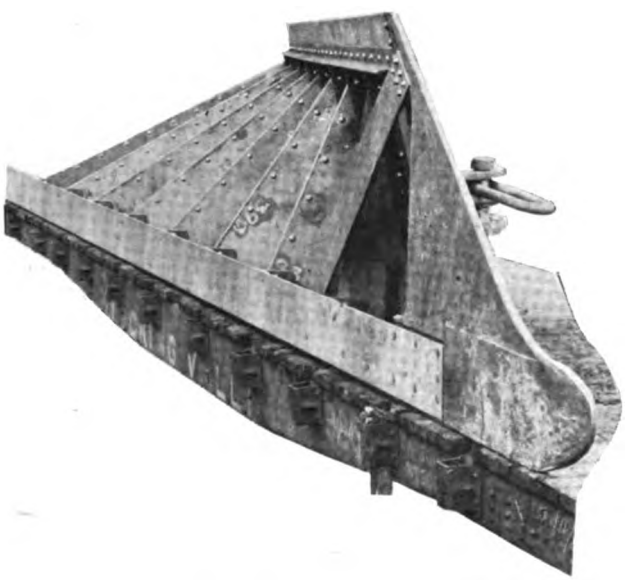
Bucyrus Side Plow
The Bucyrus Company



Marion Center Ballast Unloader
The Marion Steam Shovel Co.



Osgood Side Plow, Front View
The Osgood Company



Osgood Side Plow, Back View
The Osgood Company

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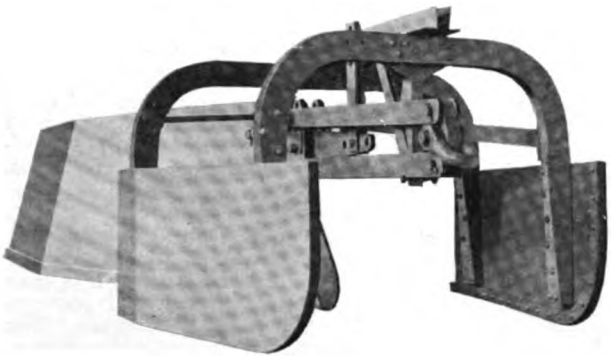
that one of its two converging sides moving diagonally to the direction of pull carries the plowing face while the other is a longitudinal beam moving close along one side of the car in the direction of pull. Ballast plows are usually built of wood and steel, sometimes with sheet steel plowing faces, which are



Osgood Center Plow
The Osgood Company

about four to five feet high, inclined slightly back and inward and long enough to span the car at a convenient angle. They are braced from within the angle by a series of beams or struts which with the faces form the body of the plow. The plow is carried on a flat behind the rear car of ballast in readiness to be pulled forward over the train at the end of a steel strand cable usually wound on the drum of a ballast unloader equipped with a stationary engine, which receives steam from the locomotive to which the unloader car is coupled.

BALLAST, SAND. Any hard, granular, comminuted rock which will pass through a No. 10 screen and be retained on a No. 50 screen. (A. R. E. A.)

Typical Sand Ballasted Track

Sand erodes easily, but can be tamped and worked readily when damp, is dusty when dry and fine, and is used where ballast material of larger particles is unobtainable. When clean and coarse it is also valuable as a covering for ties and rail bases to prevent sun checks and excessive expansion. It drains fairly well, but becomes foul more readily than coarser ballast and is difficult to tamp solidly when dry. It is found mixed with natural gravel deposits and is desirable in pit-run gravel ballast in proportions of 25 per cent to 50 per cent. It is frequently used for a first raise, on which stone or other coarser material is added.

BALLAST SCREEN. A device, usually of wire mesh, woven steel rods or perforated metal, used to sift the fine materials which fall through the apertures from the coarser stone or gravel ballast particles which, being too large to pass through, are retained on the screen.

A screen commonly used to clean ballast is composed of ¼ in. steel rods woven with ¾ in. by 8 in. mesh fastened to the lower edge of a shallow, bottomless, rectangular boxed frame of wood or iron. The screen is braced in an inclined position at such an angle that fine particles mixed with ballast, when thrown against the screen near the top, will fall through the apertures as the material rolls down over the mesh, while the ballast is retained separately at the bottom of the incline.

Rotary screens are usually hollow cylinders of sheet iron, perforated with circular holes over the entire surface and held in frames inclining longitudinally at angles suitable for separating the fine and coarse particles by rotating while the material descends from the upper entrance to the lower delivery end. They are variously mounted but usually receive ballast from conveyor belts or buckets at the upper end and deliver it into chutes at the lower end.

Screens in large ballast crushing and screening plants are commonly of the inclined stationary type, arranged to hold on the mesh and distribute the coarse particles to the crushers, bins or cars while the finer material drops through to another screen, or is otherwise disposed of. The general arrangement is to sift, separate and dispose of all the material in successive steps by gravity following the initial lift.

BALLAST, SLAG. A vitrified residue from a blast furnace, or other ore reduction furnace. Slag breaks usually with sharp, glassy edges which tend

Typical Slag Ballasted Track

to cut into the fibre of the tie. It is not uniform in character and in some cases tends to disintegrate from frost action, though generally it gives fair satisfaction under moderate traffic.

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BALLAST, STONE. Stone broken by artificial means into small fragments of specified sizes for use as a support for the track structure. Stone of suitable sizes for ballast is sometimes found at the bases of declivities or steep mountain slopes, as well as in large deposits of distintegrated rock which require little working beyond the drilling and blasting necessary to loosen it from its natural bed. Most of the stone used as ballast, however, is quarried, crushed, screened to pass through a 2 or 2½ in. ring and to be retained on a ¾ in. ring, and is sometimes washed to free it from dust. An advantage of this non-absorbent and permanent material is the excellent drainage which it affords the rough-surfaced, sharp-edged particles binding together in such a manner as to distribute the loads uniformly over greater areas than less stable ballast, thus requiring a minimum depth to hold the track in line and surface. It is especially applicable to heavy-traffic main lines where the firmest possible foundation is important.

Typical Stone Ballasted Track

In selecting stone for this purpose, the desirable qualities are considered in the following order of importance: (1) maximum weight per cu. ft., (2) minimum absorption in pounds per cu. ft., (3) per cent of wear minimum, (4) hardness, maximum, (5) toughness, maximum, (6) cementing value, minimum. Tests of these qualities are furnished gratis by the U. S. Department of Agriculture, Washington, D. C., where information concerning prior tests of various kinds of stone is also obtainable in tabulated form, as well as plans of stone testing machinery.

Although broken stone meets the many requirements of ballast for railway tracks better than any other material, the natural deposits of suitable and available rock are not so equitably distributed as to avoid long hauls, while the initial expense for preparation in large quantities involves the opening of quarries and the installation of crushing, screening and loading plants. Crushed rock is not an easily handled material and the cost of maintaining the track involving the working of rock ballast is considerable as compared with gravel ballast. It is preferably laid over some sub-ballast such as cinders or pit run gravel without which it tends to sink into the earth of the roadbed, making it necessary to clean it at intervals of five years or less. This operation is expensive, particularly on double or multiple track lines where the stone between the tracks is so solidly compacted that it must usually be loosened before it can be handled with forks or shovels in the limited space available.

Limestone, granite and trap are the varieties of rock most widely used for ballast. The harder sand stones are also crushed for ballast, but to a less extent. The following tentative specifications for stone ballast are under consideration by the A. R. E. A.:

Specifications for Stone Ballast

Physical Qualities

General. Stone for use in the manufacture of ballast shall break into angular fragments which range with fair uniformity between the maximum and the minimum size specified herein; it shall test high in weight, hardness, strength and durability, but low in absorption, solubility and cementing qualities.

Tests. Tests shall be made as follows:

Weight.—Not less than one-half cubic foot of the stone accurately measured, and dried for not less than twelve hours in dry air at a temperature of between 125 and 140 degrees Fahrenheit shall be weighed. The weight shall not be less than .... lbs. per cubic foot.

Note.—Of the stone available, that having the maximum should be used; a high quality stone for ballast will weigh 168 lbs. per cubic foot.

Strength.—Two-inch cubes of the stone shall be sawed to reasonably accurate dimensions and the top and bottom faces made accurately parallel. For the primary tests, the test specimens shall be dried for two hours in dry air at a temperature of between 120 and 140 degrees Fahrenheit and at the time of test the temperature of the specimen shall be not less than 50 degrees. Tests shall be made in a testing machine of standard form and the stone shall have a compressive strength of .... lbs. per square inch.

Note.—Of the stone available, that having the maximum compressive strength should be used; a high quality stone for ballast will have a strength of 10,000 lbs. per square inch.

A secondary test shall be made on specimens the same in all respects as for the primary test except that the blocks shall have been completely immersed in clean water, of a temperature between 35 and 90 degrees, for 96 hours, the test to be made within 30 minutes of removal from the water.

If the compressive strength shall have decreased more than .... per cent from the primary tests, the rock shall be deemed unsuitable for ballast purposes.

Note.—Of the stone available, that showing the least difference between the results of the primary and secondary test should be used; a high quality stone for ballast should show not over 1 per cent difference.

Solubility.—One-fourth cubic foot of the rock shall be crushed and thoroughly washed. The particles shall then be placed in a glass vessel and covered with clear water. The vessel shall be thoroughly shaken for five-minute periods at 12-hour intervals for 48 hours. If any discoloration of the water occurs, the rock shall be deemed soluble and undesirable for use as ballast.

Test No. 1. Wear or Durability.—One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 inches, and exposed to a dry heat of from 125 to 140 degrees Fahrenheit for a period of two hours. After the dried stone is carefully weighed it shall be given 10,000 revolutions in a tumbler approximately four ft. in diameter, of not less than two cubic yards capacity, and operating at 25 revolutions per minute.

The sample shall then be passed over a screen of the minimum dimension provided for sizing the ballast, again washed and dried in the same manner as before the test, and again carefully weighed.

If the decrease in weight shall be more than ..... per cent of the original weight of the sample, the stone shall be deemed unfit for use as ballast.

Outside of the breakage, which is exhibited by the small particles which will pass through a minimum screen but will not pass a sieve of 20 meshes to the inch, the wear should not exceed .... per cent.

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Note.—Of the stone available, that showing the smallest loss in weight should be used; a high quality stone for ballast will show a loss of not more than 1 per cent in fragments which will pass a screen of 20 meshes to the inch, and not more than 3 per cent in those passing the minimum sizing screen.

Test No. 2 (Quick Weathering Test). One-half cubic yard of stone shall be dried and weighed as for Test No. 1. It shall then be immersed in water for six hours and then while still wet, be placed in a refrigerating plant and subjected to a temperature of approximately zero Fahrenheit for two hours. It shall then be removed and the temperature gradually raised in two hours to 100 degrees and that heat continued for two hours, when it shall be immersed as before and again subjected to approximately zero temperature.

The freezing and thawing shall be repeated to a total of ten exposures. If any tendency to disintegrate is observable the stone should be considered unsuitable for ballast. Otherwise the material shall again be subjected to a wear test as provided under Test No. 1. If in this wear test the maximum decrease in weight shall be in excess of .... per cent, it shall be deemed unsuitable for use as ballast.

Note.—Of the stone available, that showing the minimum average decrease in weight should be used; a high quality stone for ballast will not show a decrease in fragments which will pass the minimum sizing screen of more than 4 per cent.

Absorption. One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 inches, and exposed to a dry heat of from 125 to 140 degrees Fahrenheit for a period of 6 hours. After the dried stone is carefully weighed it shall be submerged in clean water for a period of 96 hours. It shall then be removed from water and exposed to a normal air in the shade and at a temperature between 40 and 80 degrees, and allowed to drip for 30 minutes, when it shall again be weighed and the difference in weight shall be used to determine the rate of absorption. Stone showing an absorption of more than .... lb. per cubic foot is unsuitable for ballast.

Note.—Of the stone available, that showing the minimum absorption should be used; a high quality stone for ballast will have an absorption of not more than 0.50 lb. per cubic ft.

Cementing Quality. A 5-lb. sample of the rock thoroughly washed and dried shall be crushed until it will pass through a screen of one-fourth inch mesh. This material shall be placed in a bill mill which contains two steel shot weighing 20 pounds each, and the mill revolved at the rate of 30 revolutions per minute, until it has made 2,000 revolutions for each pound of sample in the mill.

Sufficient clean water shall be added to make a consistent mortar, which shall then be molded into 1-inch cubical briquettes, formed under 10 pounds pressure. All of the briquettes shall then be allowed to dry 20 hours in air, when one-third of them shall be tested for compressive strength.

One-third shall be kept for four hours in a steam bath, and the remainder shall be immersed for four hours in clean water at a temperature between 50 and 60 degrees Fahrenheit and then tested for compressive strength.

If in any of these tests a compressive strength greater than .... lb. per square inch is developed, the material shall be deemed unsuitable for ballast.

Note.—Of the stone available, that from which the briquettes show the minimum strength should be used; a high quality stone will show not to exceed 4 lbs. per square inch.

Requirements

Breaking. Stone for ballast shall be broken into fragments which range with fair uniformity between the size which will in any position pass through a 2½-inch ring and the size which will not pass through a ½-inch ring.

Test for Size. *Maximum.*—A sample weighing not less than 150 pounds shall be taken from the ballast as loaded in the cars and placed in or on a screen having round holes 2¼ in. in diameter. If a thorough agitation of the screen fails to pass through the screen 95 per cent of the fragments, as determined by weight, the output from the plant shall be rejected until the fault has been corrected.

Minimum.—A sample weighing not less than 150 lbs. shall be taken from the ballast as loaded in the cars; weighed carefully and placed in or on a suitable screen having round holes ½ in. in diameter. The screen shall then be agitated until all fragments which will pass through the screen have been eliminated. The fragments retained in the screen shall then be weighed and if the weight is less than 95 per cent of the original weight of the sample, the output of the plant shall be rejected until the fault is corrected.

Handling. Broken stone for ballast must be delivered from the screen directly to the cars or to clean bins provided for the storage of the output of the crusher. Ballast must be loaded into cars which are in good order and tight enough to prevent leakage and waste of material and are clean and free from sand, dirt, rubbish or any other substance which would foul or damage the ballast material.

Inspection. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the ballast material is prepared and loaded in accordance with the specifications and contract.

In case the inspection develops that the material which has been or is being loaded is not according to specifications, the inspector shall notify the manufacturer to stop further loading and to dispose of all cars under load with the defective material.

As the quarry deepens or is enlarged, further tests shall be made of the material wherever conditions indicate a change in the quality of the stone, or where in the judgment of the engineer for the company a further test is advisable. Should such tests show that the stone fails to meet the provisions of these specifications, it shall not be used for the manufacture of ballast.

Measurement. Ballast material may be reckoned in cubic yards or by tons as expedient. Where ballast material is handled in cars, the yardage may be determined by weight, after ascertaining the weight per cubic yard of the particular stone in question by careful measurement and weighing of not less than five cars filled with the material, or the tonnage may be determined for subsequent cars by measurement and converting the yardage into tonnage by use of the weight per yard as determined above.

BALLAST TAMPER. A portable self-propelling machine designed to operate two or more tamping bars for compressing ballast under the ties of railway track. The tamping tool weighs 40 lb. to 45 lb. and is operated by one laborer. The power is usually compressed air but sometimes electricity where current is available. It is delivered to the tamping tools by air hose or insulated cables, each tool being supplied and operated separately. Where electricity is used it is either taken from an existing source of supply to compress air for air-operated tools or it is generated from a portable plant and furnished to tools on which motors are mounted. The tendency of the past few years has been toward mechanical tie tamping on main trunk line tracks ballasting with crushed stone, the usual unit being the four-tool machine.

BALLAST TAMPING. The ramming and prying together of particles to solidify ballast under the ties. This is done especially beneath and for 15 in. to 18 in. on each side of the rail bearings to give adequate support to the ties and enable them to transmit the loads from the rails to the road bed.

Ballast may be tamped by hand with shovels, picks or bars or by means of power tamping machines.

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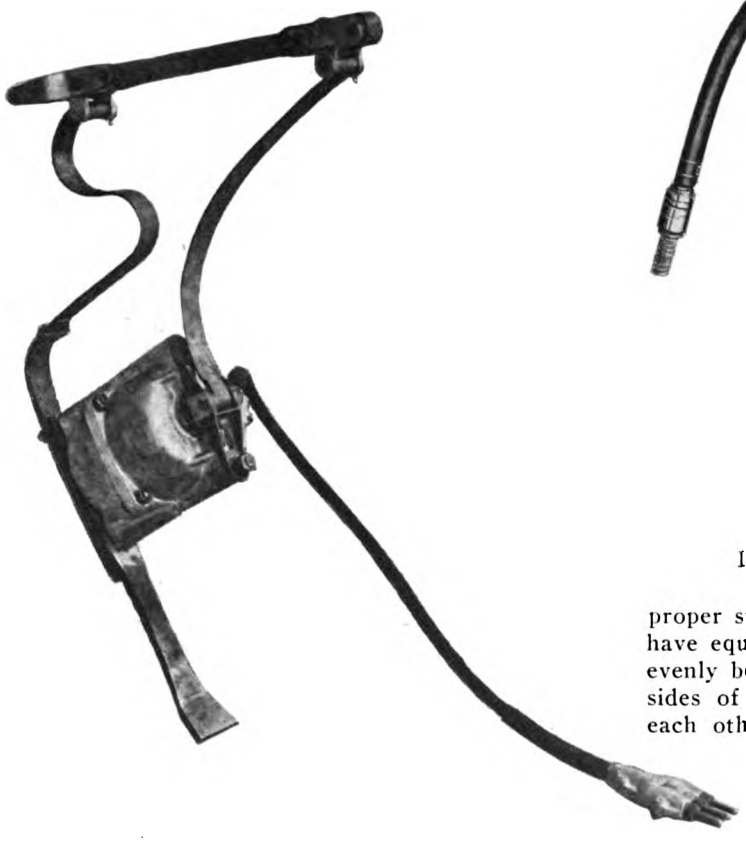
Although tamping is a comparatively simple operation and apparently demands little or no skill, it really requires experience and dexterity on the part of the laborer as well as the constant care and judgment of the foreman and supervisor to obtain the desired results at a reasonable cost. The track is first lifted on jacks set between the ties to bear up under the bases of the rails at suitable intervals, usually at the centers, quarters and joints.

Ballast should be tamped most solidly under the rail bearings, and it naturally follows that these portions of the tie must be tamped first. Whether tamping outside the rail or between the rails, the tool should be first inclined so that the ballast directly under the rail base may be thoroughly tamped to start with, the work proceeding from this point rather than toward it. The act of tamping should be clearly understood to apply to working the ballast under the tie and not against its sides as is usually attempted by those unskilled in the work. While tamping track the supply of loose ballast being used should be kept to a level of approximately two inches above the bottom of the tie.

The ends of a tie from the rail bearing outward are preferably tamped first, the portion between the rails being left if possible until a train or two has passed over the track and settled the ties on their beds. Here again the portions under the rails



Electric Tie Tamping Unit
The Kalamazoo Railway Supply Company
(See Page 728)

should receive the first and most thorough tamping, working 15 in. to 18 in. inward. The remaining central portion of the tie is more lightly tamped or the ballast is merely shoveled under and tramped down between the ties, depending on the character of the ballast and the permanence of surface sought.

New track is preferably ballasted with shovels, the road bed being usually new and without sub-ballast so that both time and traffic must pass before the track structure will settle solidly on its bed. Shovel tamping will readily compact the ballast as firmly as the new road bed on which it rests, and further solidification is a waste of effort. It requires experience and judgment to shovel-tamp ballast under a series of ties so as to maintain track in

Imperial Pneumatic Tie Tamping Unit
The Ingersoll-Rand Company

proper surface, for not only must the ends of a tie have equally compact beds but all the ties must be evenly bedded. Shovel ballasting proceeds on both sides of a tie simultaneously, two laborers facing each other and thrusting their shovel blades into the loose material about four inches from the tie. With one foot on the shoulder of the shovel blade, the worker bears some weight on the tool, at the same time drawing the handle slightly toward him and thus prying the ballast in under the tie, the movement being repeated at about a slow walking gait. Four men usually tamp the ballast outside the rails, two at each end of the tie, and later four men tamp the same tie between the rails, two on each side of the tie. Shovel tamping is also considered good practice for lifts higher than 3 in. in any ballast.

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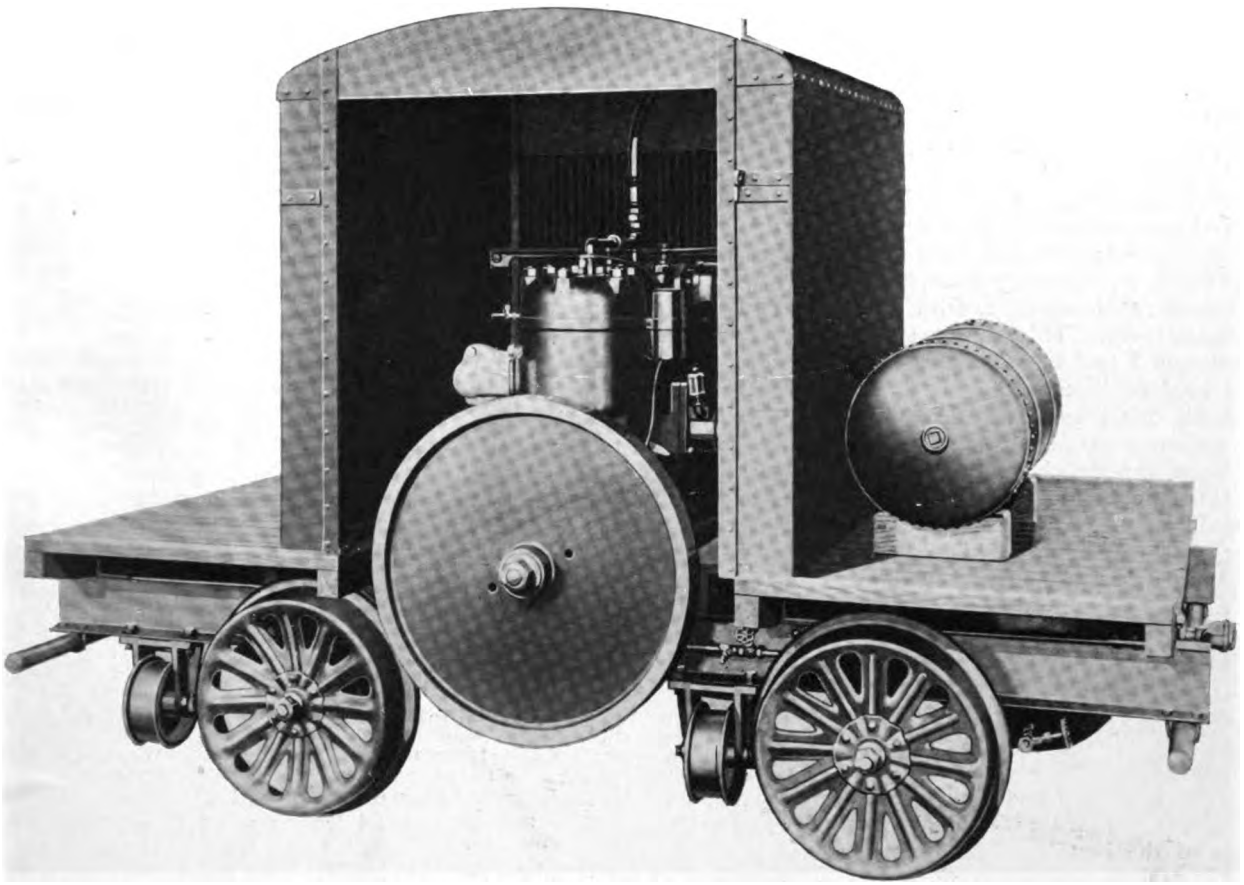
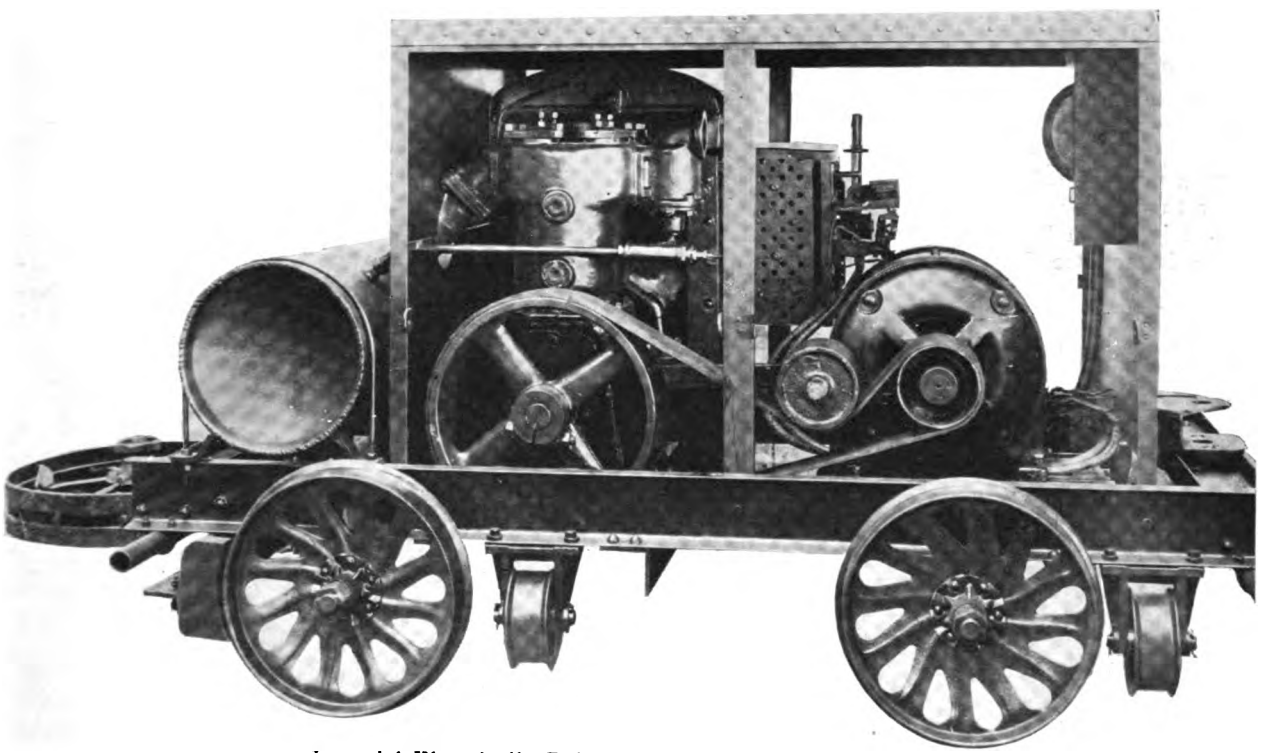


Imperial Gasoline Engine Driven Tie Tamper Compressor Car
The Ingersoll-Rand Company



Imperial Electrically Driven Tie Tamper Compressor Car
The Ingersoll-Rand Company

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The harder materials such as crushed gravel, slag and stone are preferably tamped by means of ballast picks, tamping bars or power tamping machines, when the track is to be lifted less than 3 in. in one operation. If the lift is high, the track is raised temporarily on jacks, when a part of the ballast will roll under the ties. The remaining space is then filled by pushing the material under the ties with shovel blades and thoroughly shovel tamping it. If the lift is less than 3 in. and picks are used, each laborer works alone, stooping over the tie and pounding the particles beneath it with the blunt end of the tamping pick. This end is about ½ in. to ¾ in. thick and 2 to 3 in. wide, the faces of least area being used for rock, while the larger faces are more suitable for softer and finer ballast. Care must be taken to avoid striking the particles so hard as to raise the tie above the general track level, and to avoid chipping the bottoms of the ties which should not be so close together as to interfere with the sweep of the pick, this tool being more effective and more generally used than the hand tamping bar.

With a view to decreasing the manual labor of tamping ballast with a pick, which usually necessitates standing on the ties and stooping well over while striking into the ballast 8 to 12 in. below the laborer's feet, the iron tamping bar about 5 ft. 6 in. long over all, steel tipped and weighing about 14 lb. was brought into use. It has a straight shaft and a blunt pounding end similar to that of the ballast pick, but inclined forward about 30 deg. from the axis of the handle. The blow obtained with this bar is probably not effective in crushed stone ballast at depths of more than 3 in., although the weight of the bar has a direct influence on the force exerted, this method being usually reserved for light lifts in hard ballast. More uniform and effective blows and faster work are possible with the power tamping machine, which usually obtains power from a portable internal combustion engine compressing air to operate two or more short tamping bars that are hose-connected to the compressor which is mounted with the engine on a self-propelling car. Electric power is also sometimes used to compress air or to directly propel the hand tool, where the current is obtainable from existing power lines or in the latter case from portable motor generator outfits.

One laborer manipulates the power tamping tool by holding the handle, guiding it while it strikes and controlling the power by means of a valve or switch attached to the tool. By this method it is feasible to tamp effectively under ties of switches, frogs and crossings which are difficult to reach with hand tamping tools. Owing to the comparative rapidity, effectiveness and ease with which power tamping is done the use of these machines is increasing on trunk lines using crushed rock ballast.

The following tentative instructions for ballasting have been suggested by the A. R. E. A.:

(1) Earth or Clay Ballast:

Tools: Shovel equipped with iron cuff or handle; broad-faced tamping bars.

Method: Tamp each tie from 18 in. inside of the rail to the end of the tie with the handle of the shovel or tamping bar. If possible, tamp the end of the tie outside of the rail first and let a train pass over before tamping inside of the rail; give special attention to tamping under the rail; tamp the center of ties loosely with the blade of the shovel; the dirt or clay between the ties should be placed in layers and firmly packed with feet or otherwise, so that it will shed the water quickly; the earth should not be banked above the bottom of the ends of the ties; the filling between the ties should not touch the rail and should be as high as, or higher than, the top of the ties in the middle of the track.

(2) Cinder Ballast (Railway Product):

Tools: Shovel, tamping bar or tamping pick.

Method: Same as for gravel.

(3) Burnt Clay Ballast:

Tools: Shovel only in soft material. When burnt very hard, tamping pick or bar should be used.

Method: Tamp 15 in. inside of the rail to the end of the tie, tamping the end of the tie first, letting a train pass before tamping inside of the rail; tamp center loosely; tamp well between the ties; dress ballast same as for earth or cinders.

(4) Broken Stone or Furnace Slag:

Tools: Shovel, tamping pick, stone forks.

Method: Tamp 15 in. inside of rail to the end of the tie; if possible, tamp the end of the tie outside of the rail first and allow a train to pass over before tamping inside of the rail; tamp well under the rail; tamp well under the ties from the end of same; do not tamp the center of tie; finish in accordance with standard section.

(5) Chats, Gravel or Chert Ballast:

Tools: Shovel, tamping pick or tamping bar. For light traffic, shovel tamping is sufficient. For heavy traffic, the tamping pick or tamping bar should be used. The tamping bar is recommended instead of the tamping pick for ordinary practice.

Method: Tamp solid from a point 15 in. inside of the rail to the end of the tie; if possible, tamp the end of the tie outside of the rail first and allow a train to pass over before tamping inside of the rail; care should be taken not to disturb the old bed. A tie should be tamped solidly from the end, using pick or tamping bar. After the train has passed, the center of the tie should be tamped loosely with the blade of the shovel; dress same as stone ballast.

(6) General:

When not surfacing out of face, as in the case of picking up low joints or other low places, the general level of the track should not be disturbed. Where the rails are out of level, but where the difference in elevation is not excessive and is uniform over long stretches of track, a difference in elevation between the two rails of ⅛ in. may be permitted to continue until such time as the track would ordinarily be surfaced out of face.

BALLAST UNLOADER. A friction-drum pulling machine with operating devices, consisting essentially of an engine, usually connected horizontally and in tandem to a grooved steel drum, around which a cable, used to pull an unloading plow over cars loaded with ballast, may be wound; the machinery being commonly mounted as a unit on a base of wood or metal suitable for placing on the floor of a car. The unloader engine is usually a steam engine taking power from the locomotive and for this purpose is located at one end of the car with a pressure reduction valve on the connecting steam line to limit the pulling power to the strength of the cable, a 20-car train being usually unloaded in about ten minutes by this method.

The capacities of ballast unloaders vary from about 20 tons to 60 tons straight pull with a steam pressure of 125 lb. The steam unloader engine usually has two cylinders, one located at each of the forward corners of the base, which is about 5 ft. wide by 30 ft. long, and preferably of heavy iron.

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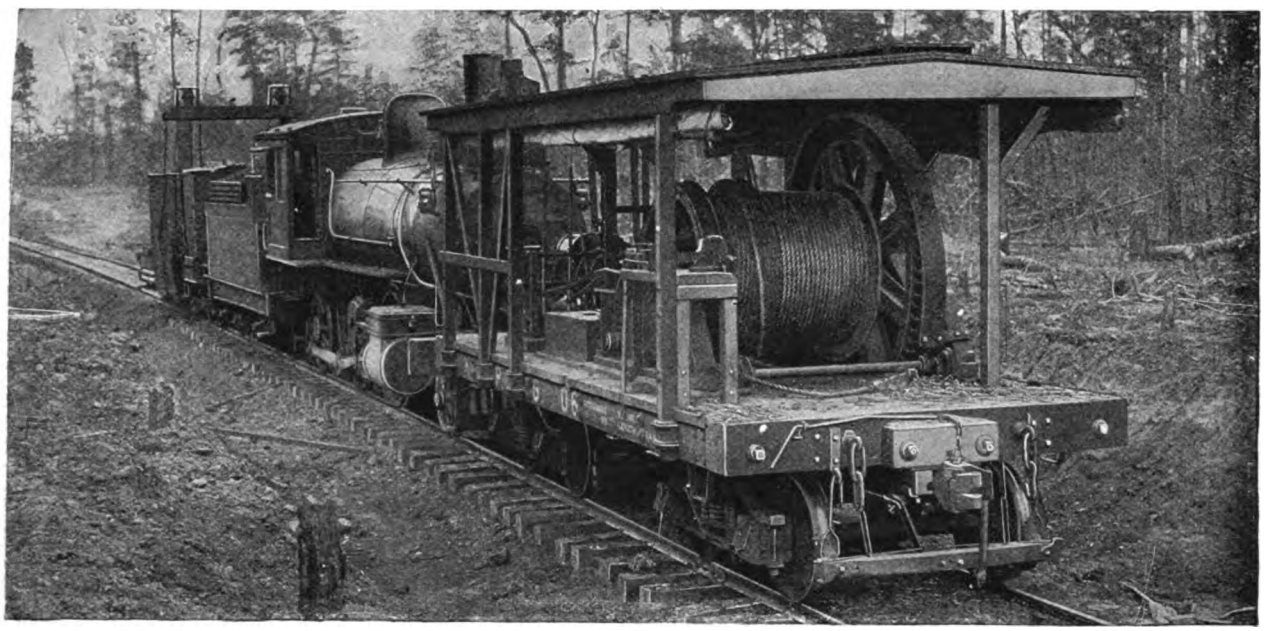
The cylinders are about 12 in. by 12 in., and are connected by driving shafts to fly wheels at each end of a cross shaft on which is mounted a small gear which engages a larger gear on an intermediate cross shaft which ends in a winch head and also mounts a small gear which in turn engages the drum gear which has a face of 6 in. to 8 in. and a diameter of about 3 ft. 6 in., while at the opposite end of the drum is a friction flange around which a metal band, usually mounting a series of hard wood blocks, is secured and operated by means of a hand or foot lever.

BALLAST UNLOADING. The removal of ballast from cars to the road bed. The manner of distributing ballast along the track is determined largely by the kind and quantity of the equipment available for the purpose, two general methods being in common use: (1) convertible cars or flat cars equipped with end aprons so that a ballast plow may be used to sweep the loads off on either or both sides, or (2) cars from which the loads may be dumped by tilting the car body or parts of it.



Lidgerwood Ballast Unloader
The Lidgerwood Manufacturing Company

Unloading by the first method involves clearing the ends of the cars of all obstacles above the floor surface such as end gates and brake wheels, if any, and stretching a wire strand cable the length of the train, one end being coupled to the apex of the ballast plow at the rear while the other end is attached to and wound on the drum revolved by an unloader engine deriving power from the locomotive at the front end of the train. The distribution of the material along the road bed in thin layers or all in one spot is regulated by the rate of movement of the train while unloading is in progress.

The cable is commonly drawn off the drum of the unloader and over the loaded cars preparatory to unloading, by means of span chains stretched across the track about 12 ft. above the rails between two opposite poles or by means of a horizontal spar of timber extending at right angles over the loaded train from a stretcher car stationed on a parallel track. The cable is run through snatch blocks attached with chains to stakes in the stake pockets on the loaded flat cars preparatory to unloading on curved track, though such guides are not usually necessary for work on straight track. Convertible cars used in this service are equipped with removable ends and sides hinged at the top and arranged to open outward from the floor line. An advantage of flat cars is that the roughest material a steam shovel will load can be handled as described, affording a method of disposal from a pit of the largest boulders or other refuse material for filling or rip rap; although the available space on flat cars limits their ballast capacities to from one-third to one-half the yardage that can be carried in convertible cars of the same length.

Ballast may also be unloaded with the locomotive of the ballast train only, by detaching it from the loaded train to pull the plow forward at the end of the cable. With this expedient, the distribution of the ballast cannot be controlled, as the train is stationary while being unloaded, and the cable is not so readily handled without the unloader drum, for it must be thrown off the unloaded train by hand and replaced partly by hand, which is slow and at times dangerous to employees.

Side dump cars are also sometimes used to unload ballast at the side of the track. This style of car is usually equipped with a special compressed air cylinder so arranged that the cars may be dumped toward either side from the locomotive where the air control is located or they may be released separately at the car. The car body is secured and supported along the center line to a horizontal draft beam held in position by braces from the truck frames, and high enough to permit the body to tilt sharply to discharge all the contents, the

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usual angle being about 45 deg. Some side dump cars have sides which lower automatically when the bottom tilts, forming a floor extension to discharge the load away from the rail, while other styles have end lever devices which hold the side up while the load is discharged from the tilted floor beneath it.

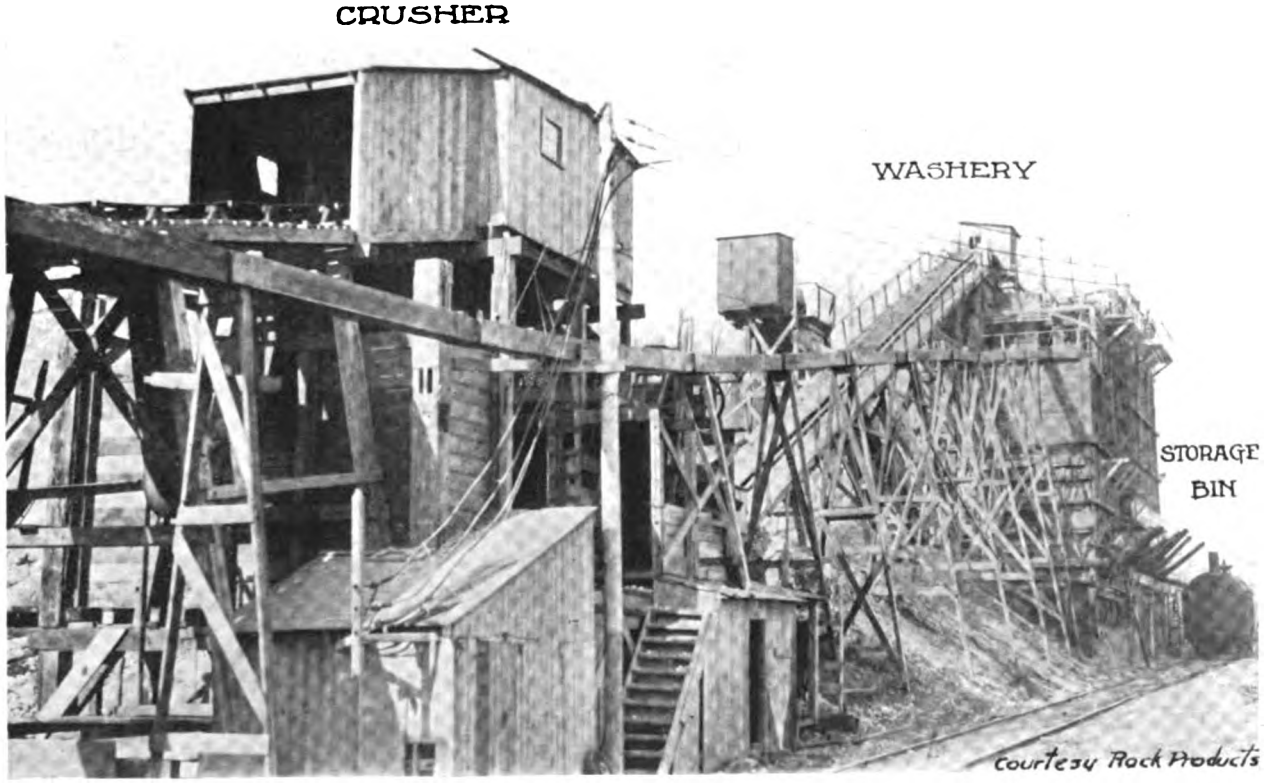
It is frequently desirable and sometimes obligatory to unload ballast between the rails. This method tends to prevent the loss of ballast over the sides of narrow embankments as well as the obstruction of ditches in cuts and the spaces between tracks, signal connections and other devices which occupy positions on the road bed beyond the ends of the ties. For this method of unloading, center dump cars are necessary, followed by a spreader to level the material down to avoid obstructing traffic. Center dump cars are commonly equipped with tripping devices which allow the horizontal double-leaved car floors to part above the center line of the track and dump the ballast between the rails, one-half the length of the car being unloaded at a time if desired. The ends of the car commonly slant in and down with a view to clearing the load automatically by tripping a lever at each end of the car. The distribution of material is made continuous by moving the train ahead slowly as successive cars are cleared of their loads by the lever operators, while the spreader at the rear of the train levels down such material as does not fall into place beneath or between the blocked-up ties.

BALLAST WASHERY. A system of water jets arranged to play on crushed rock or gravel ballast material to cleanse it from impurities as it descends in chutes during the process of manufacture. Usually the force of the water jets is applied in a direction opposed to the flow of the crushed ballast at the crushing plant, retarding its descent in the chute somewhat while freeing the particles from earth, dust, roots, etc., which are carried away with the waste water while the heavier ballast drops into bins or cars after passing the screens below. See Ballast, Gravel.

BAR, CLAW. A steel track tool designed to withdraw track spikes from ties.

It is about 5 ft. long over all, having an inclined forked working end resembling a pair of claws, so shaped and beveled on their adjacent edges that they can be wedged firmly astride the neck of the ordinary cut track spike, beneath the head, in such a way as to pry it up without slipping when leverage is applied to the handle of the bar. The toe of the claw is about 2¼ in. across at the widest point and the space between the toes varies from ⅝ in. to 11/16 in. wide, depending on the size of the spike for which it is designed. The shank is rectangular in section from the claws upward about 18 in. and gradually tapers from that point into a rounded handle, 1⅛ in. in diameter, which usually terminates in a wedge-shaped end used for prying track members into place.

A style of claw bar sometimes used is supplied with a heel placed on the shank behind the claw so that when the bar is revolved on the heel, the leverage will not be decreased by the point of contact moving away from the ends of the claws. Another style is the goose neck claw bar which differs from the straight style in that it has a short backward



A Ballast Washery

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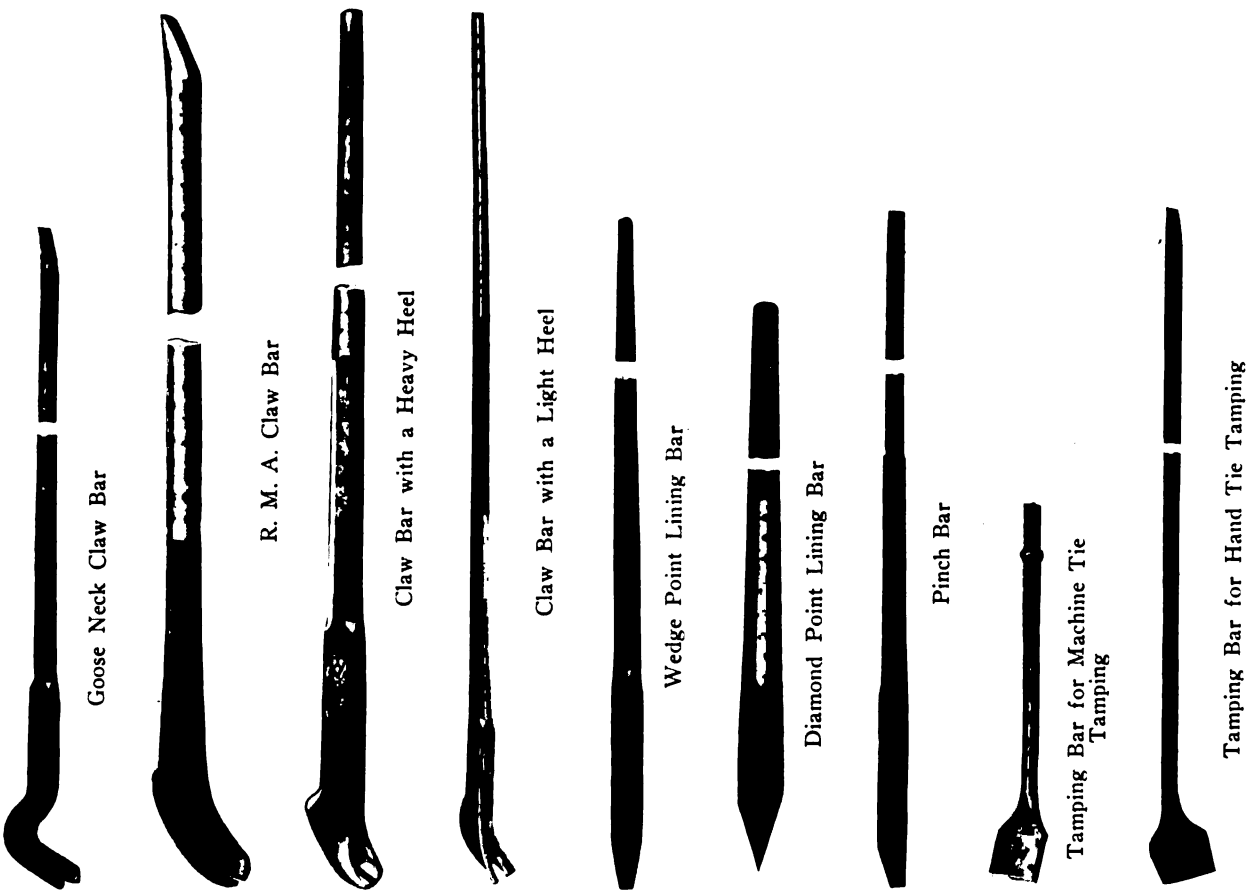

(See Pages 706, 829 and 832)

curve at the bottom of the shank which acts as a fulcrum for the lever. This is an excellent tool with which to pull spikes without bending them after they have been started with a straight claw bar.

BAR, LINING. A steel tool used as a lever to line and shift track.

This straight steel bar is about 5½ ft. long over all and usually weighs about 25 lb., having a wedge-shaped or diamond-pointed working end and a square or octagonal shank of about 1½ in. steel, tapering to a round handle about ¾ in. in diameter. In shifting track, the wedge-shaped end of the bar is driven diagonally into the ballast under the rail so that by prying up against the flange of the rail the track is lined to the desired position.

BAR, PINCH. A straight steel lever of general utility in maintenance of way work. The weights of pinch bars vary widely, the trackman's bar weighing about 25 lb., being 4 ft. 9 in. long over all. with a chisel-shaped working end, an 18 in. shank about 1⅝ in. square in section, and a round handle tapering to 1$\frac{1}{16}$ in. diameter at the top.

BAR, TAMPING (Ballast). An iron hand tool weighing about 14 lb., designed to ram and compact particles of ballast under the ties of a railway track. The tool is a round-handled bar about 5 ft. 6 in. long overall, with a straight shaft and a working head which is inclined about 30 deg. from the axis of the shaft, terminating in a blunt steel striking end which has a rectangular working face about ½ in. to ¾ in. thick and 2 in. to 3½ in. in width, at right angles to the axis of the bar handle. The angle of the working head facilitates the striking of blows to drive the material diagonally down beneath the ties.

BASE (Switch Lamp). The bottom part of the lamp, which carries the body, the lighting device and the top. The base is usually fastened to the top of a socket casting which secures the switch lamp to the spindle of the switch stand, or the lamp is supplied with a tubular socket on each side, through which are thrust the two upright prongs of a U-shaped fork, to the base of which is fastened the socket casting.

BASE PLATE (Frog). The bed plate to which a frog, crossing, slip switch or other form of special track work is riveted, bolted or clamped to provide a more rigid support and connection between the various parts.

BELL CRANK, CENTER HOUSING (Slip Switch). A flat steel, right angle crank casting pivoted to the center housing of a slip switch in such a manner as to form the connection between the reach rod and the connecting rod to the center points. See Reach Rod (Slip Switch).

BELL CRANK, END HOUSING (Slip Switch). A flat steel, right angle or T-shaped crank casting, pivoted at the junction of the arms to the end housing of the slip switch. See Housing, End (Slip Switch).

BERME. A bench of unbroken or approximately level ground left at the top of an excavation or the bottom of an embankment.

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To provide a protective base for an embankment, a minimum space, usually eight feet wide, is commonly left between the toe of the slope of the roadway and the top of the adjacent borrow pit slope unless the ground is very soft, when the berme is widened or borrow prohibited. Waste banks are located far enough back from the tops of slopes of excavations to leave room for parallel surface drains with bermes on each side to prevent eroded material from the waste bank from obstructing the ditch, while the ditch intercepts the water which would flow over and tend to erode the slope of the excavation. Bermes or terraces are also introduced into slopes, usually where the bottom material will stand at a steeper slope than the surface excavation. A cut made in earth and loose rock at slopes of 1½ to 1 may rest on solid rock half way down to grade, in which case the bottom half may be taken out at a slope of 1 to 1 and a berme left at the change of slope.

BEVEL ANGLE (Guard Rail). The angle of the slope at which the end of the guard rail is beveled.

BEVELED END (Guard Rail). The slope at the end of a guard rail designed to prevent loose or hanging parts of moving equipment from catching the end of the guard rail. The bevel is usually made by cutting the rail at an angle of 45 deg. from the vertical cross sectional plane, so that the length of the rail measured on top will be less than the length measured on the bottom. The ends of guard rails are sometimes depressed instead of being beveled. See Chamfer Cut.

BEVELED WING END (Frog). The vertical bevel or slope at the end of a frog wing, usually made at an angle of 45 deg., to prevent loose or hanging parts of moving equipment catching on it.

BLOCK, HEEL (Frog). A block which spans the joint and fills the space between the adjacent rails at the heel of a frog. The heel block is provided with the same drilling as that in the joint bars outside, the whole being firmly held together by bolts. The heel block is ordinarily used instead of two inside joint bars where the adjacent rails at the heel of the frog are too close together to permit the use of joint bars or the tightening of track bolts.

BLOCKING. One of a number of wood or metal separators used between the parts of frogs and switches, or between a running rail and a guard rail to keep the parts in their correct relative positions and sometimes to act also as foot guards.

The standard practice of the A. R. E. A. as to the use of blocking is as follows:

The heel of a frog should be made with a steel filler block, to fit the section of rail, securely bolted, and with the outer end of the filler planed off ¾ in. below top of rail to act as a riser for the outer edges of worn treads.

The wings and throats of all frogs, switches and guard rails should be blocked with metal or wood blocks, shaped to fit rail sections, and to give 1⅞-in. vertical flange clearance, and be bolted or otherwise secured.

BLOCK, MIDDLE (Frog). A filler block in built-up frogs used between the point and the heel blocks, to preserve the proper width of flangeway.

BLOCK, TOE (Frog). A metal filler sometimes installed at the connecting rail joints at the toe of the frog. It spans the joints, fills the space between the adjacent rails, and is provided with the same drilling as the opposite joint bars which are held to it by bolts which pass through the three parts. In addition to acting as a separator, strengthener and foot guard, the toe block performs the function of an anti-creeping device.

BODY (Switch Lamp). The sheet metal case carrying the lenses, and to which the top and base are fastened. The body exclusive of the top and the base fixture is usually about 9 in. high and of about 9 in. in diameter, between the faces of opposite lenses.

BOLT, FOOT GUARD. A bolt used to secure the foot guard to the webs of the adjoining rails. See Turnout. Also Switch. Also Frog.

BOLT, GUARD RAIL END BLOCK. A bolt used to secure the end block to the webs of the main rail and the guard rail.

BOLT, HEAD LOCK. A special washer or device which prevents the head of a bolt from turning. See Frog, Crossing.

BOLT, HEEL BLOCK. A bolt used in fastening the heel block in place between the rails. See Frog. Also Switch.

BOLT, HOLD DOWN HOUSING (Frog). A bolt used in fastening the hold down housing to the base plate of a frog.

BOLT, MAIN FROG. A bolt used to secure the point and wing rails of a spring frog together, or to fasten together the point rails of a rigid, bolted frog.

BOLT, SPRING (Frog). A bolt used at the throat of a spring rail frog to attach the spring housing to the wing rail and to hold the coil spring and follower in place to adjust the spring pressure.

BOLT, TOE BLOCK. A bolt used to fasten the connection block at the toe of a frog between the joint bars. Toe blocks are not always used.

BOLTED FROG. A rigid frog of which the wing and point rails are bolted together.

BORROW PIT. An excavation made outside the limits of the roadway to obtain material for the embankments.

Borrow pits are usually selected in order to obtain earth at the shortest possible distance from the fill or to make up the deficiency of excavation from cuts of standard widths at either end of the fill. They generally extend between the roadway berme and the right-of-way boundary line, have 1½ to 1 side slopes and plane bottom surfaces graded to drain water. They frequently furnish all the earth for long, low fills and for the bases of high fills.

BRACE STOP (Frog). A brace used on a spring rail frog to receive the side thrust when the movable wing rail is in the open position. The brace stop is somewhat similar in form and function to the rail brace. See Frog, Spring Wing Rail.

BRACE (Switch Lamp). The sheet metal strap which holds the cap in position above the lamp top, in about the same relative position as the cap on a smoke jack.

The switch lamp cap is usually supported on four of these small riveted braces which hold it an inch

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or more above the lamp top to which they are secured.

BRACE, SWITCH RAIL. A specially strong rail brace commonly used to fit against and support the stock rail of a switch against lateral thrusts from the gage side, which tend to crowd it out and spread the gage. The switch rail brace is frequently made with a long base having several spike holes, or the brace is designed to back against the upset end of a special switch plate, or it is made as a portion of a combination one-piece switch plate and rail brace. See Rail Brace.

BRIDGED JOINT (Rail). A rail joint formed with joint bars, one or both of which extend below the bases of the rails. The extension may be a depression in the wide horizontal leg of the angle bar, or an extension of metal from the central portion of the bases, or the entire horizontal leg of the bar may be folded under so that the rail base fits closely between the two inside surfaces of the fold. These various joint bar extensions are designed for the purpose of strengthening and supporting the joint, to obtain as nearly as possible a continuous girder effect throughout the line of rails and joints.

BRIDLE ROD. See Switch Rod. Also Switch.

BROKEN BASE (Rail). A rail flange from which a piece has broken or which has developed a crack which may cause a base failure. Broken flanges and cracks at the web angles are common forms of broken base. See Rail Failure.

BROOM, SNOW. An implement for sweeping snow and ice from railway switches, flangeways, etc.

It is commonly a small, coarse, heavy duty broom consisting of a flat bundle of splints of split bamboo,

Double Band Snow and Switch Broom | Bamboo Snow Broom | Bamboo Fibre Snow Broom

rattan or wire, about 16 in. long, the lower free ends forming a stiff, slightly spreading brush while the

Upright Frog and Switch Broom | Steel Wire Frog Broom

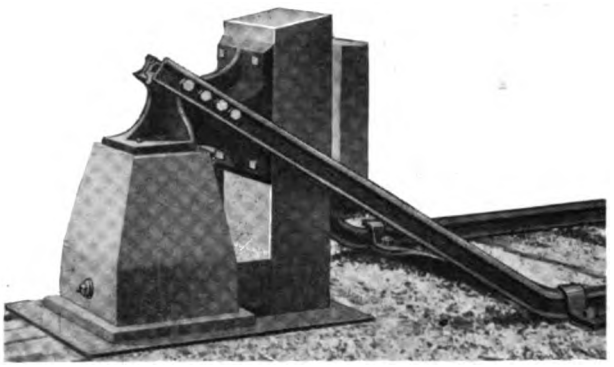
upper portion is laced together with twine or wire and sometimes incased at the shoulder in a metal, wire-laced band which holds the splints firmly together, in line with and around the butt of the round wood handle, which is about 3½ ft. long and is usually shod at its upper end with a short, metal

Chisel Point Snow Broom Handles

ferrule holding a chisel-pointed steel spud for loosening ice, or other material which is too hard to be removed by sweeping.

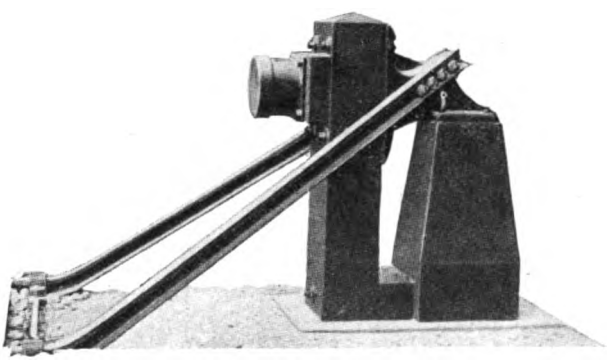
BUMPER. Any structure or obstruction located at the terminus of a stub track with a view to preventing rolling stock from going off the ends of the rails. See Bumping Post.

BUMPING POST. A braced post, a block or other car stopper, placed at the end of a stub track to prevent rolling stock from going off the ends of the rails. Bumping posts are preferably designed to stop cars in such a manner as to do the least possible damage. The steel or wood post is planted up-



Ellis Freight Bumping Post
The Mechanical Manufacturing Co.
(See Page 747)

right between the rails on a strong foundation of crossed or trussed timbers, of steel girders or of concrete, a contact block usually being secured to the



Ellis Passenger Bumping Post
The Mechanical Manufacturing Co.
(See Page 747)

front face of the post to receive the blows from car couplers. From the bearings of this block two diagonal anchor rods or braces diverge forward and downward to form joints with the running rails, or to fastenings in the foundation beneath the cross ties. The compression bracing behind the post, also designed to prevent the post from overturning, con-

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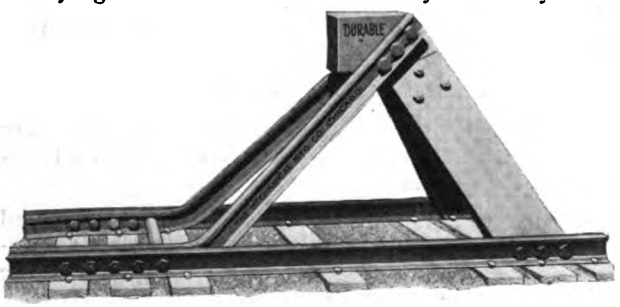
sists sometimes of an auxiliary block and a brace casting, or a casting on rails or rods braced to the rail ends or foundation. The hydraulic bumper used principally at passenger terminals is a bumping post carrying a contact block with a hydraulic cylinder



Durable Bumping Post
The Mechanical Manufacturing Co.
(See Page 747)

which has a long stroke piston which acts as a shock absorber when the post is struck by a car. Some other contact blocks are equipped with rubber cushions or coiled steel springs behind the striking plate.

Modifications of the bumping post include a device presenting to car wheels a gradual-stop incline of successive segmental depressions in the top edges

Trasco Car Stop
The Track Specialties Co.
(See Page 817)

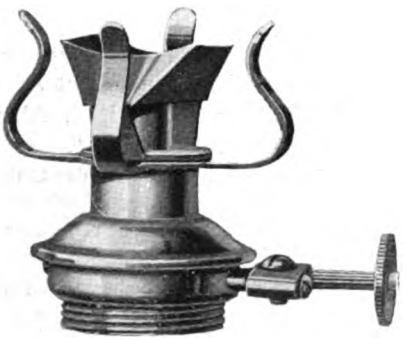
of steel castings of the diameter of the wheels and increasing in depth from front to rear; also the concrete bumper which is a mass of reinforced concrete, usually rectangular or wedge shaped with a con-

Buda Bumping Post
The Buda Co.
(See Page 660)

tact block bolted across its face at coupler height to receive the shocks of moving cars. Loose material such as cinders, gravel or sand is sometimes piled at the end of a track and enclosed on sides and rear with low walls of masonry extending about five feet above rail level. Similar materials without walls are also used, but take up track room, have to be replaced frequently and are unsightly. Any well-designed bumping post properly placed will stop cars drifting at reasonably low speed. While it is possible to make a post which will stop a car which has attained high speed, it is inadvisable because the damage to the car and its contents due to striking an immovable post will usually exceed the cost of renewing and replacing a post, which a rapidly moving car would demolish.

BURNER, SWITCH LAMP. A metal wick-holding and flame-regulating device secured on the top of the oil fount.

The burner usually supports and loosely holds the base of a short, cylindrical glass chimney, and is perforated around and below the flame to afford necessary ventilation. The wick rises from the fount through the burner usually to a flame spreading de-



Long Time Burner
The Armspear Manufacturing Co.

vice at the top. Its height is regulated by sprockets attached to a horizontal shaft attached near the base of the burner. By turning the shaft, the sprocket points engaging the wick raise or lower it, and so regulate the flame at its upper end. Wide burners with ribbon wicks produce flat flames. The light from such a burner consumes the wick so quickly that daily attention is necessary to remove incrusta-

Chimney-less Burner
Peter Gray & Sons
(See Page 700)

tion, which reduces the flame and tends to cause the lamp to smoke the lenses and obscure the light. Burners with circular flames only about 3/16 in. in diameter have been developed to reduce the heat produced, which tends to melt the solder in the lamp parts, while the tubular wicks with soft felt cores draw oil more readily, but are themselves consumed more slowly, so that the lamp needs attention only

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twice a week or at even longer intervals. These are called long-time burners..

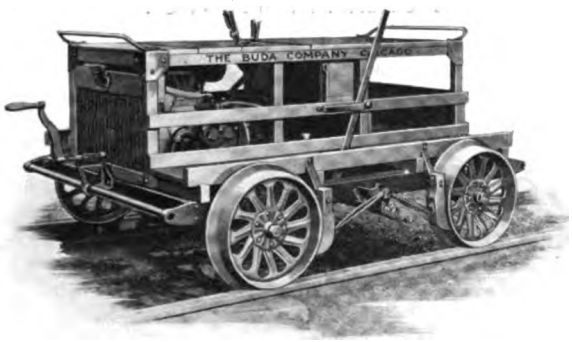
Chimneyless burners are also advocated to prevent diagonal flames, unevenly trimmed wicks or inaccurately centered chimneys resulting in smoking the lamp and obscuring the light or reducing its candle power. A disadvantage of such burners is the decrease in the intensity and regularity of the flame. See Switch Lamp.

CAR, BALLAST. See Ballast Car. Also Dump Car.

CAR, MOTOR. A motor-driven railway work or inspection car designed primarily to minimize the time spent by maintenance employes in traveling over the tracks on duty.

Motor cars are equipped with internal combustion engines and ignition systems operated by means of throttle and spark levers conveniently located in front of the operator who therewith controls the speed of the car. The engines may be either two-cycle, or four-cycle, the term cycle indicating a full movement of the piston in one direction. Every complete revolution causes the piston to move ahead to the limit and then back to the starting point, this complete revolution or power stroke corresponding to two cycles. The two-cycle engine is built to afford an explosion and power impulse at every revolution, or every two cycles. The four-cycle engine is designed to afford an explosion and power impulse after two complete revolutions, or every four cycles. The engines of both types are usually kept cool by means of a circulation of air or sometimes of water around the cylinders.

Buda Direct Connected Section Car
The Buda Co.
(See Page 658)

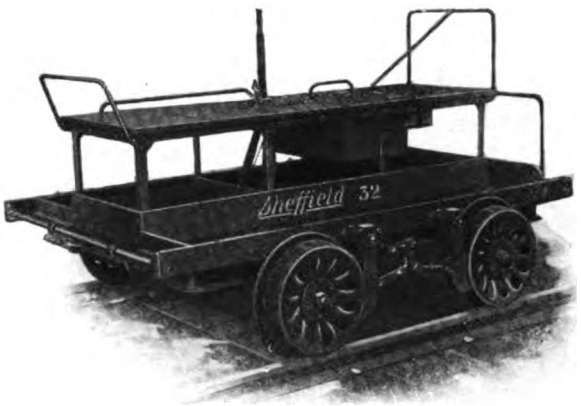


Buda Friction Drive Section Car
The Buda Co.
(See Page 658)

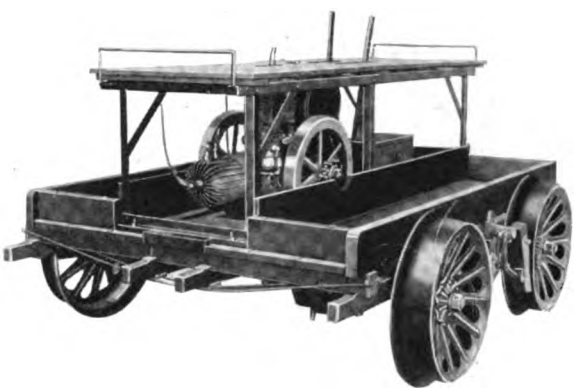
Motor cars are of three general types, (1) section and heavy duty work cars, (2) light inspection cars, (3) party inspection cars. All of these types are four-wheeled cars with seating capacity for one or more persons. The engine and its frame are placed either at one side or in the center of the car between the wheels, the two styles being distinguished by the terms side load and center load cars.

A common style of center load section or heavy duty car has a bench seat extending the entire length of the car and occupying the middle third of the platform space. This type of car is usually equipped either with a centrally located one-cylinder or two-cylinder, two-cycle or four-cycle, direct connected engine with gears or chain drive; or a free running engine with gear, belt, chain or friction drive transmission. Engines which are directly connected are started by pushing the car along the track, whereas a free running engine may be started while the wheels are motionless and the car then placed in operation by engaging the gears or friction disc. This section or heavy duty type of car, which will seat 6 to 8 men, usually has ample power at the same time to pull a loaded trailer and is used principally by trackmen and bridgemen. Section motor cars in common use weigh from about 850 lb. to 1250 lb.

The side load light inspection car usually carries a tool tray and slat type platform, the seat being on the engine side over the body wheels of the



Sheffield Section Car
Fairbanks, Morse & Co.
(See Page 686)



Kalamazoo Section Car
The Kalamazoo Railway Supply Co.
(See Page 727)

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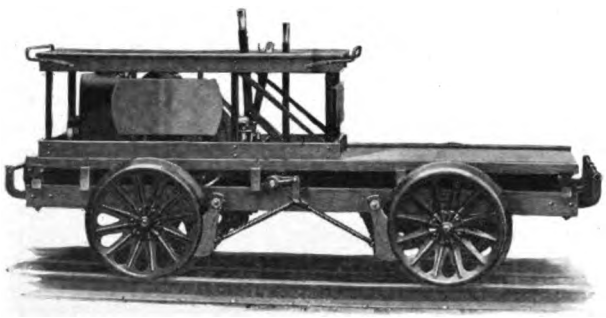
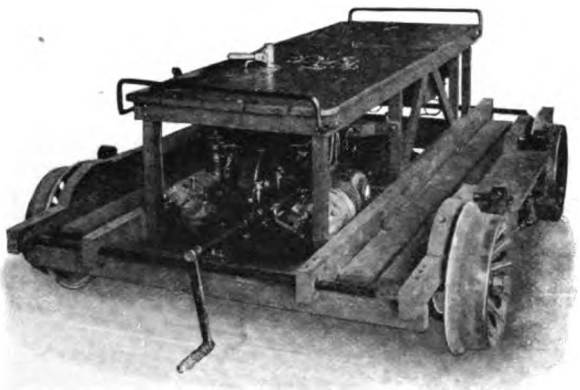
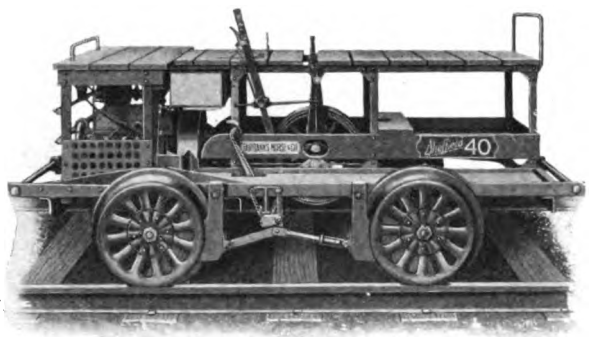


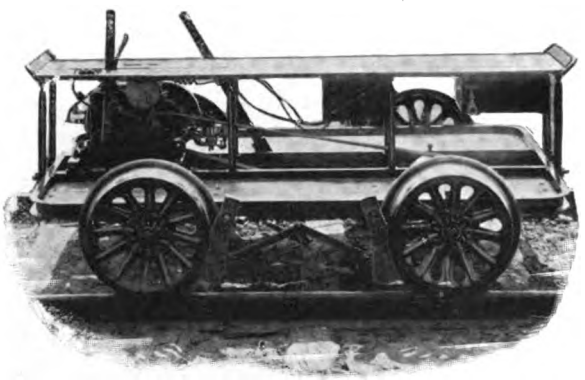
Fairmont Bridge and Extra Gang Car
The Fairmont Gas Engine and Railway Motor Car Co.
(See Page 691)



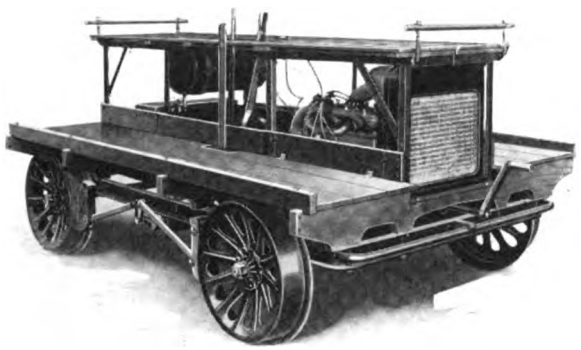
Mudge Heavy Duty Car
Mudge & Co.
(See Page 750)



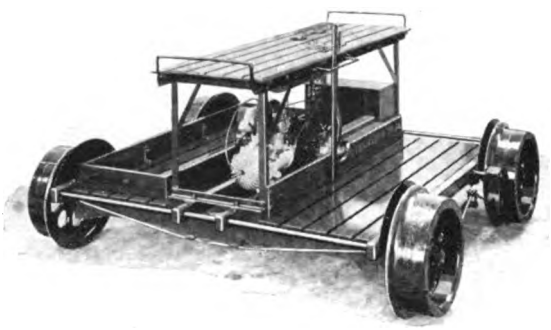
Sheffield Heavy Section Car
Fairbanks, Morse & Co.
(See Page 686)



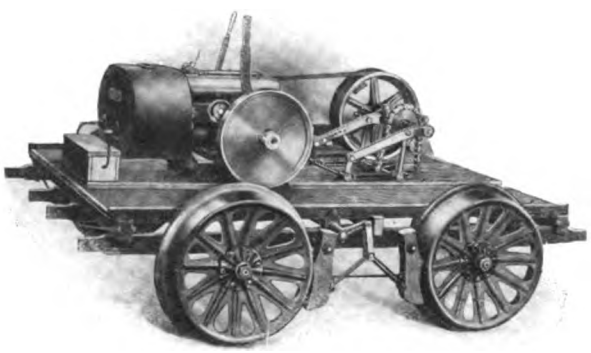
National Standard Section Car
The Northwestern Motor Co.



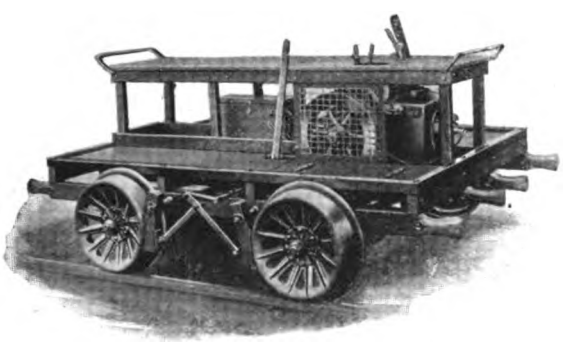
Kalamazoo Heavy Duty Car
The Kalamazoo Railway Supply Co.
(See Page 726)



Mudge Inspection Motor Car
Mudge & Co.
(See Page 750)



Woolery Engine Applied to Car
The Woolery Machine Co.
(See Page 839)



National Motor Car
The Northwestern Motor Co.

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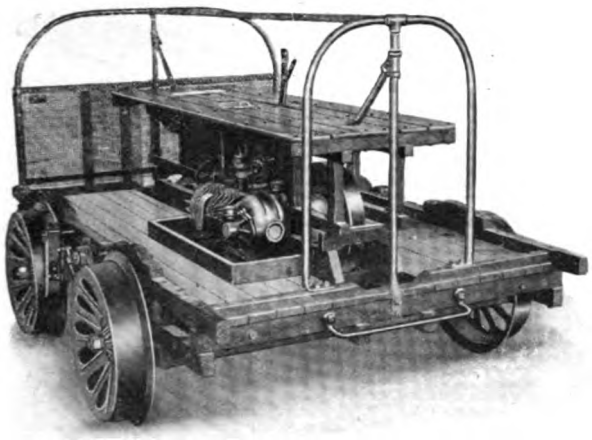
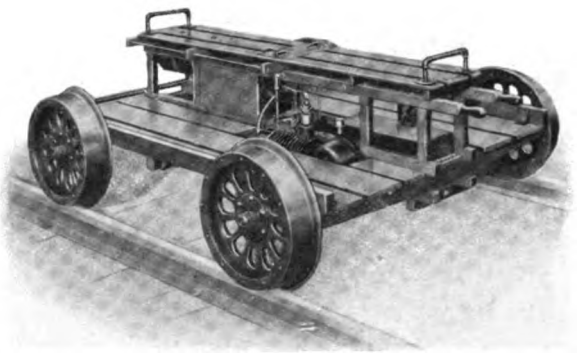
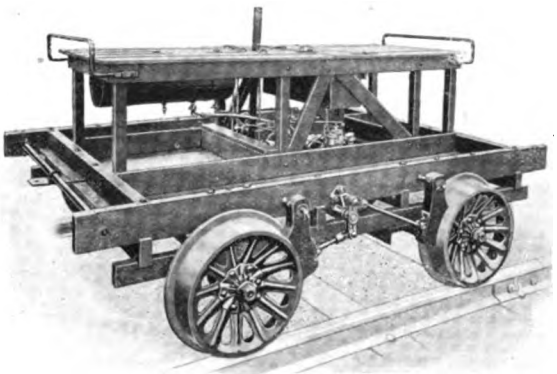


Mudge Section Motor Car
Mudge & Co.
(See Page 751)

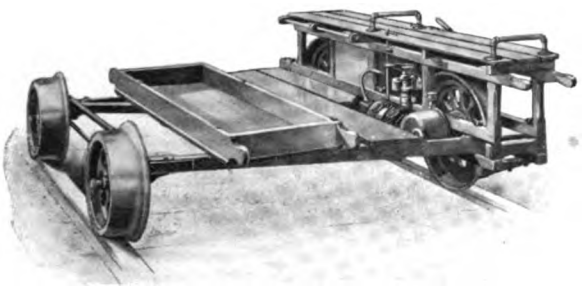


Kalamazoo Section Car
The Kalamazoo Railway Supply Co.
(See Page 726)



Mudge Inspection Car
Mudge & Co.
(See Page 751)

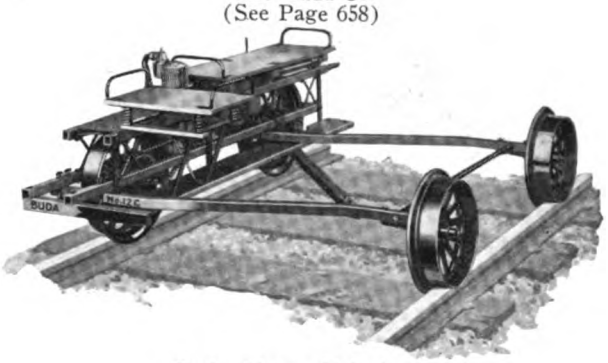
Sheffield Kerosene Center Load Car
Fairbanks, Morse & Co.
(See Page 686)



Mudge Inspection Car
Mudge & Co.
(See Page 750)

Buda Motor Velocipede
The Buda Co.
(See Page 658)

Sheffield Inspection Car
Fairbanks, Morse & Co.
(See Page 686)



Buda Motor Velocipede
The Buda Co.
(See Page 658)

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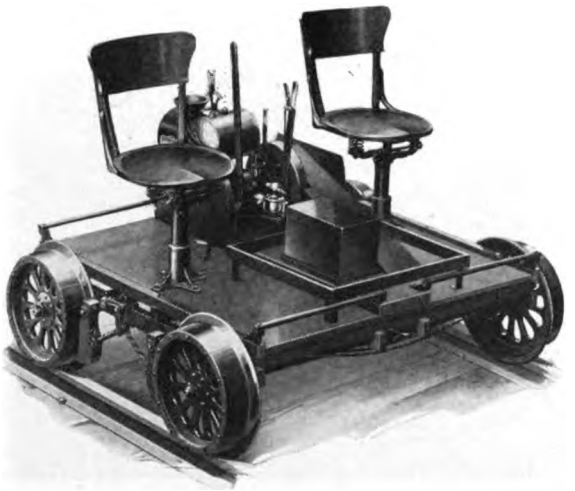
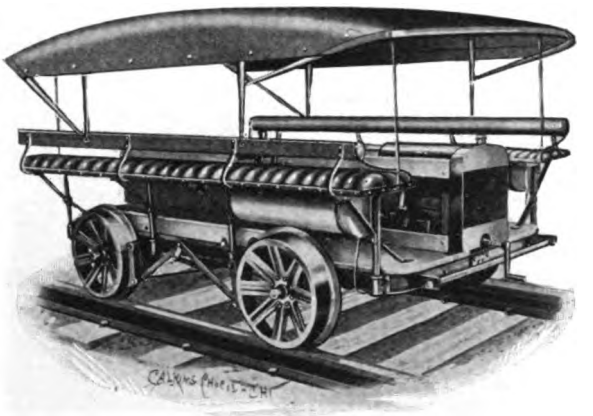
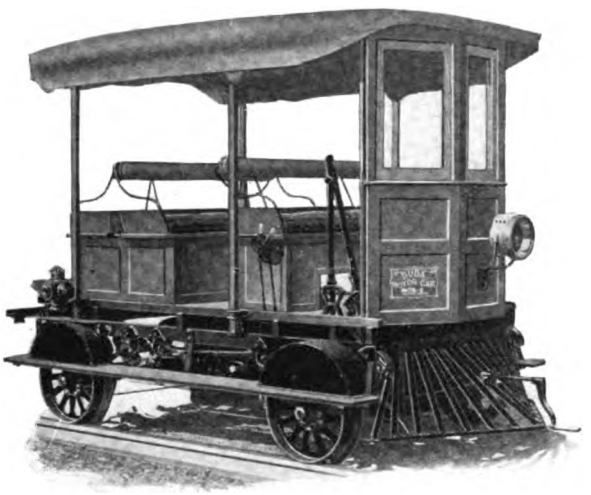


Roadmaster's Inspection Car
The Fairmont Gas Engine and Railway Motor Car Co.
(See Page 692)

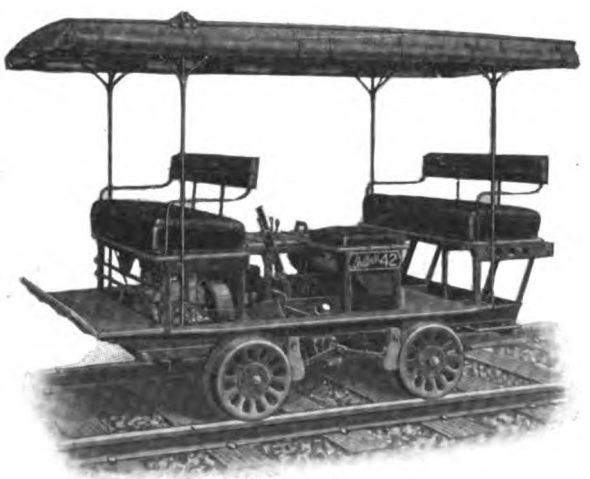


National Auto Car
The Northwestern Motor Co.

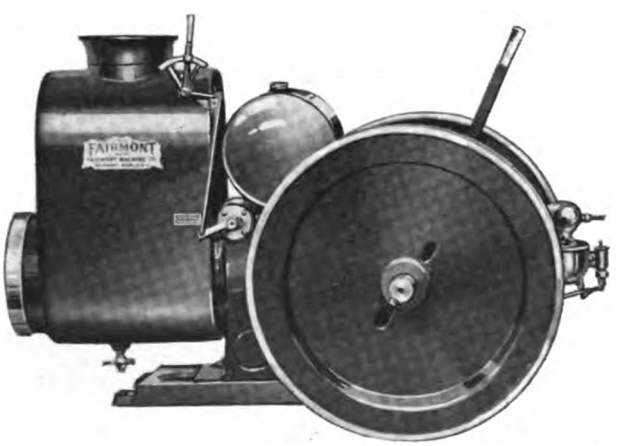


Buda Inspection Car
The Buda Co.
(See Page 658)

Kalamazoo Party Inspection Car
The Kalamazoo Railway Supply Co.
(See Page 726)



Sheffield Party Inspection Car
Fairbanks, Morse & Co.
(See Page 686)



Fairmont Motor Car Engine
The Fairmont Gas Engine and Railway Motor Car Co.
(See Page 690)

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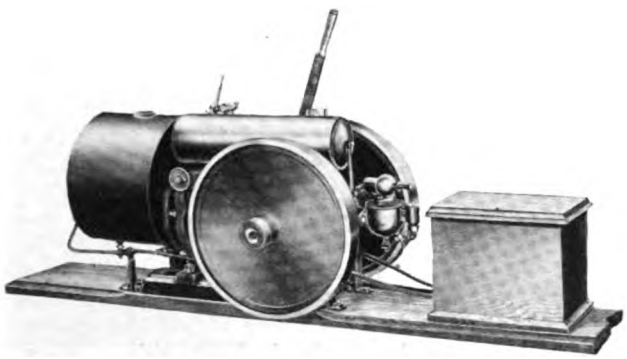
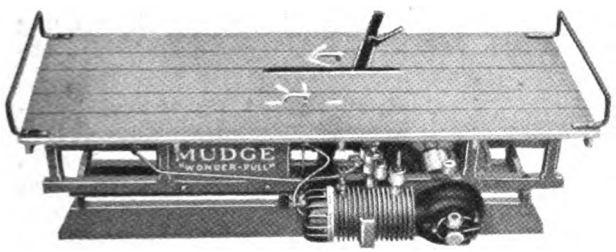
vehicle where they form a top for the frame which rests on the axle bearings and is held upright by horizontal, cross-braced guide-arms which complete the running gears and hold the wheels in their correct relative position as in the railway velocipede, which the light inspection car is designed to replace. The seats, usually without backs and sometimes furnished with handholds, are commonly placed over the power unit.

The light inspection car is equipped with either a one or two-cylindered, two-cycle or four-cycle, air-cooled, direct-connected engine centrally located between the wheels and operating directly on the rear axle, or fastened to the side of the frame and operating on the axle of the front or drive wheel. This style of car, designed to take the place of hand velocipedes of the three-wheeled and four-wheeled



Woolery Motor Car Engine
The Woolery Machine Co.
(See Page 839)



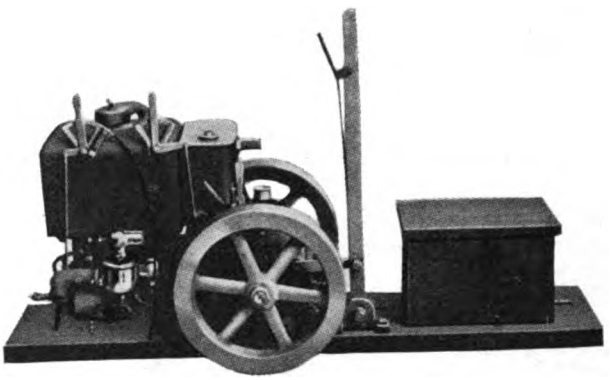
Mudge Section Car Top
Mudge & Co.
(See Page 751)

types, weighs from 350 to 500 lb. and may be disconnected readily from its guide wheels and arms for shipment by train. Center load light inspection cars are similar in design and operation to the heavier center load cars.

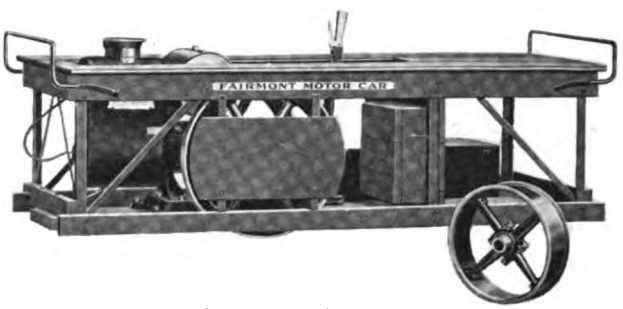
The party inspection car is unlike the section and heavy duty cars or light inspection cars in that the platform is larger, supporting one or more cross-seats (to accommodate a total of 6 to 12 persons) and a canopy top equipped with front, rear and side curtains. The engine, which is commonly of the two-cylinder opposed, four-cycle, free running type, is centrally located wholly or partly beneath the platform and has a friction disc type of transmission operating a sprocket chain to the rear drive axle. This type of car weighs from 1000 to 1500 lb. Some styles are equipped with compressed air whistles, pilots and wind shields. They are preferably operated on train orders as they are too heavy to be removed and replaced on the track readily in passing trains.

Motor-Equipped Hand Car

Another development in the railway motor car field is the motor-equipped hand car or push car. When supplied with the proper attachments and connections, the internal combustion engine may be employed to furnish power to various machines, including maintenance of way work cars. Some railway companies having large numbers of hand cars have preferred equipping them with comparatively inexpensive motor engines rather than put them aside while still in fair condition and purchase new motor cars. Other companies allow their foremen to buy the engine and outfit and use them on the



Road Boss Motor Car Engine
The North American Engine Co.



Fairmont Section Car Top
The Fairmont Gas Engine and Railway Motor Car Co.
(See Page 692)

railway hand car or push car, the fuel and repairs usually being furnished by the railway. Some of these engines are furnished with special tops made to replace the hand or push car platforms, while others are designed to be fitted on the original platform of the car. These hand car engines are either of the direct-connected type with chain or belt drive, or free running, with belt, belt and chain or friction drive transmission. Free running cars may be started while the wheels of the car are motionless and the car then placed in operation by engaging the belt, belt and chain or friction disc.

To equip a hand car with a deck and engine complete, the old platform planking over the center sills is removed, the handle-bars, A-frame, gears, etc., disconnected, and the new frame bolted to the longitudinal and cross-sills. A split pulley is sometimes fastened to the rear driving axle which is connected to the fly wheel of the engine by a wide belt; or the car is equipped with a new rear axle having a sprocket wheel, clutch and roller bearings, the

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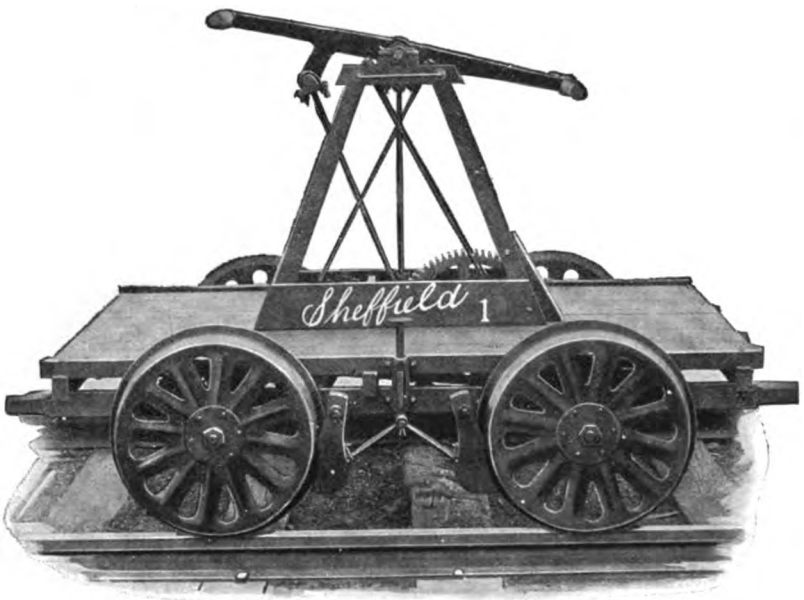
sprocket wheel being connected by a roller chain to a smaller sprocket on the side of the fly wheel. Engines without cover seats are also sometimes placed on hand cars by removing the planking of the platform over the center sills and bolting the engine frame to the longitudinal and cross-sills. The cover seat, similar to a standard motor car deck, is sometimes built over the engine, extending the entire length of the platform, or the seats are placed cross-wise or longitudinally on each side of the car.

Internal combustion engines designed for use in propelling hand or push cars are usually of the two or four-cycle, air or water-cooled, reversible types, burning either gasoline or kerosene and operated by means of a throttle, spark, clutch and brake levers, sometimes on sliding bases.

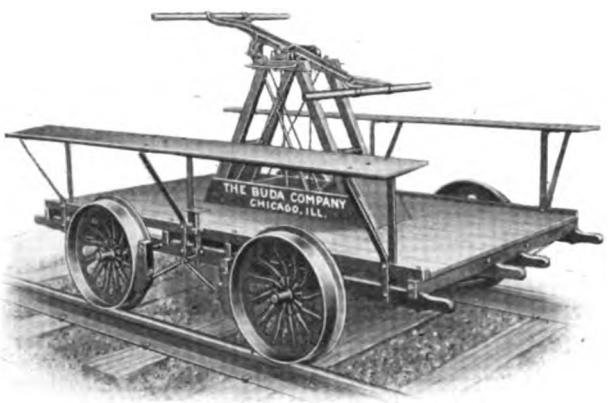
Section Hand Car
The Kalamazoo Railway Supply Co.
(See Page 726)

CAR, PUMP HAND. A four-wheeled, hand-operated railway work car supplied to maintenance employees for transporting workmen, tools, etc. An A-frame mounted on the 4½ ft. by 6 ft. wooden platform of the car supports a central walking beam, the ends of which are forked to hold wooden cross-handles which are alternately depressed to rotate the axle gear by which the car is driven, while a front brake placed on the right hand side between the wheels may be pressed to retard the speed. The longitudinal floor sills project from beneath the platform, forming handles at each end by which the car may be lifted. The wheels of hand cars operated over lines where the running rails carry electric current are insulated.



Section Hand Car
Fairbanks, Morse & Co.
(See Page 686)

CAR, PUSH. A four-wheeled railway work car designed to be pushed by hand, and commonly supplied to maintenance employees to transport track materials too bulky or heavy to be carried on a hand car, such as rails, ties, bridge timbers, switch materials, etc. This type of car usually consists of a 5½ ft. by 7 ft. wooden platform bolted to the bottom cross braces and longitudinal sills, which rest



Section Hand Car
The Buda Co.
(See Page 659)

Track Laying Push Car
The Buda Co.
(See Page 658)

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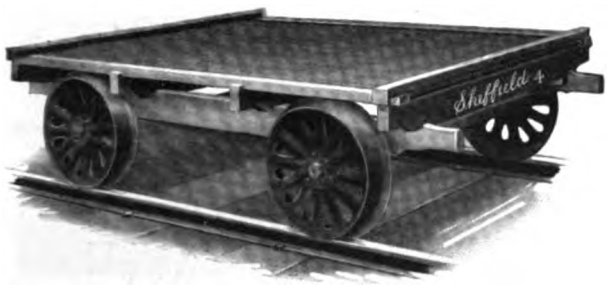

Push Car
Fairbanks, Morse & Co.
(See Page 686)

on four axle bearings and terminate in handles for lifting the car. These cars are sometimes equipped with hand brakes and insulated wheels.

CENTER POINT (Slip Switch). A switch point located at the intersection of tracks crossing each other by means of a slip switch. A center point may be a movable point or sometimes the point of a rigid frog. Commonly the movable point device is preferred as requiring less room and being more readily adaptable to the uses of a slip switch. The center point is designed to fill a larger angle than the end point, the vertical planing line crossing the head of the point rail diagonally within a distance of about 18 in. and continuing across the reinforcing rail, usually riveted to the outside of the point rail as a stiffener.

CENTER TO CENTER OF TRACKS. The distance, measured at right angles, between parallel tracks such as the distance between a main track and a side track or between any other two adjacent tracks.

The usual distance center to center of main tracks, also between main and passing tracks is 12 ft. In congested districts as in cities it is less, sometimes not more than 11 ft. In yards the average is probably not more than 11 ft. between centers of the body tracks. The present tendency is toward ample clearances between tracks where conditions permit. See clearance.

CHAMFER CUT. The shearing of a rail on a diagonal line or bevel as in a switch point. After the switch point is planed to line and proper angle the running edge is chamfered or beveled to prevent the flange of a wheel striking the side of the point. The end of a guard rail is often chamfered to prevent the catching of objects dragged from trains. See Beveled End (Guard Rail).

CHANNELING. The machine cut on the top of the head of the spring wing rail of a spring rail frog which prevents the false flanges of wheels from striking and forcing open the spring wing rail on a trailing point movement.

CHIMNEY (Switch Lamp). A transparent flame protector and smoke flue, usually a short cylinder of clear glass, set vertically over the flame with the base fitted and clamped on the burner.

CLAMP GAGE, TRACK LAYING. A track laying tool sometimes used by rail laying gangs to hold rails in their relative positions temporarily until they can be spiked to place. This tool is a steel bar resembling a switch rod, with a clamp on each end to hold the base of the rail.

CLASSIFICATION (Roadway). The grouping according to character of materials excavated for the formation of the road bed, ditches, stream and road diversions and all similar works pertaining to the construction of a railway. The specifications of the A. R. E. A., which divide all grading materials into solid rock, loose rock and earth or common excavation, are in general use.

CLEARANCE. The unobstructed distance or space between two objects; for example, the space between the level of the water and the roof of a culvert or beneath a bridge; the space between railway equipment moving on parallel tracks; and between moving trains and fixed structures such as tunnels, bridges, buildings, platforms, switch stands, etc.

Waterway clearances include provision for varying stages of water and for passage of water craft. Railway bridges over navigable streams have clearances stipulated by the Secretary for War, to whom location plans showing clearances, etc., must be submitted as a preliminary to construction or replacement.

Track clearance is the unobstructed space (measured from the plane of the tops of the running rails and from the center line of track) between equipment and loads moving over the track, and adjacent structures, including trains on other tracks. On super-elevated curved track the measurements are made from a line perpendicular to the inclined plane of the tops of the rails, at the center of the track. Main track clearances are usually wider and are considered separately from the clearances of other tracks. Clearances have been standardized by the A. R. E. A. for new, single track construction and for tunnels and bridges on steam railways, and for third rail tracks in electric zones. The vertical clearance of 22 ft. 6 in. from the top of the tie on the A. R. E. A. steam railway diagram is based on 22 ft. above the top of the rail plus 6 in. assumed as the maximum height of rail. From 8½ in. to 13½ in. above the top of the tie the A. R. E. A. recommended clearance is 2 ft. 10¼ in. on each side of the center line of track, from 4 ft. 6 in. to 16 ft. 6 in. above the tie the width is 7 ft. 6 in., narrowing to 4 ft. on each side of the center line at 22 ft. 6 in. above the tie. These minimum clearances are based on the maximum dimensions of rolling stock now in use, and are not intended to restrict grade separation projects, tracks serving freight houses, engine houses, coach yards, high level passenger platforms and other cases where these clearances are impracticable. Switch stands and fixed structures higher than 2 ft. 6 in. above the tie are recommended to be placed not less than 7 ft. 6 in. in the clear from the center of the track, and to conform to the clearance widths.

Switch stands between tracks or less than 2 ft. 6 in. high may have less clearance as required. The clearance for pouch hung cranes is measured to the nearest point of the pouch, while the coal chute clearance of 7 ft. 6 in. applies to the nearest point of the apron when not in use and the tank clearance is based on the nearest point of the spout when not in use. The recommended space between the center lines of straight parallel tracks is 13 ft. while corrections should be made in all cases on curves for overhang and super-elevation.

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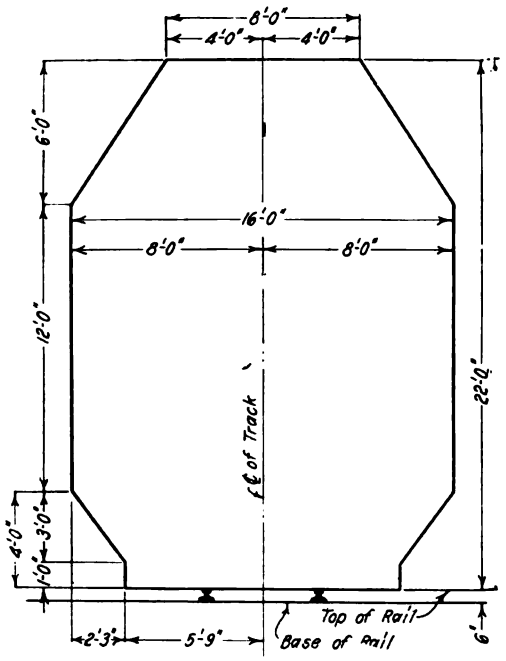
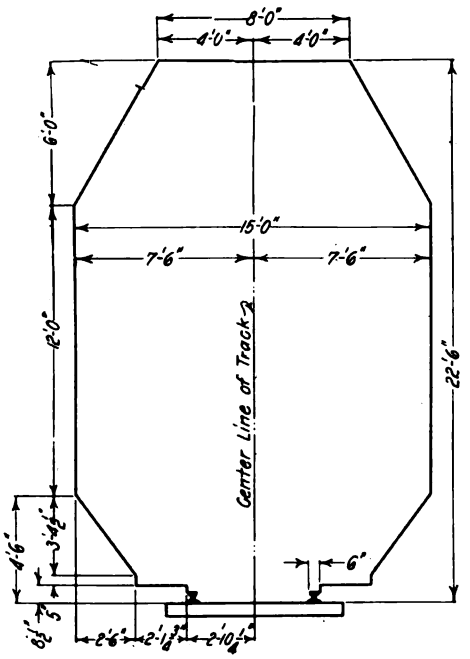
The standard minimum main track overhead clearance of 22 ft. above the top of the rail is generally observed by the railway companies of the United States, even in the congested manufacturing districts of the east, where space is restricted more closely than in the west. Overhead clearances of between 18 ft. 6 in. and 22 ft. are, however, generally allowed only when the encroachment is protected by placing a bridge warning or tell-tale on each side of and far enough from it to notify employes standing on approaching cars in time so that they may avoid being struck. Encroachments lower than 18 ft. 6 in. above the rails are not usually allowed on main tracks.

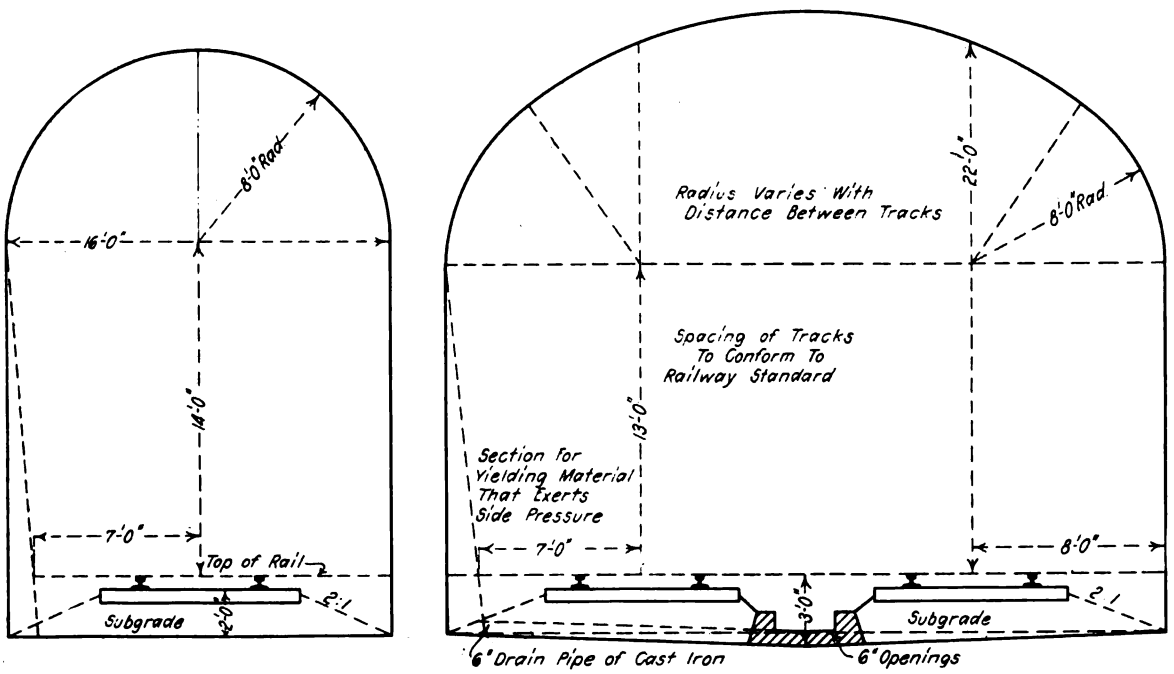
The side clearances vary on different railways. The distance between centers of main line tracks on double or multiple track lines, varies from 12 ft. to 14 ft., although the tendency is to increase this distance to at least 13 ft., and 14 ft. is considered better practice. Double track steel bridges with tracks



A. R. E. A. Standard Bridge Clearance Diagram



A. R. E. A. Standard Track Clearance Diagram



A. R. E. A. Standard Tunnel Clearance Diagram for Single and Double Track

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farther apart than the tracks on either approach are not uncommon on railways which contemplate increases in standard clearances.

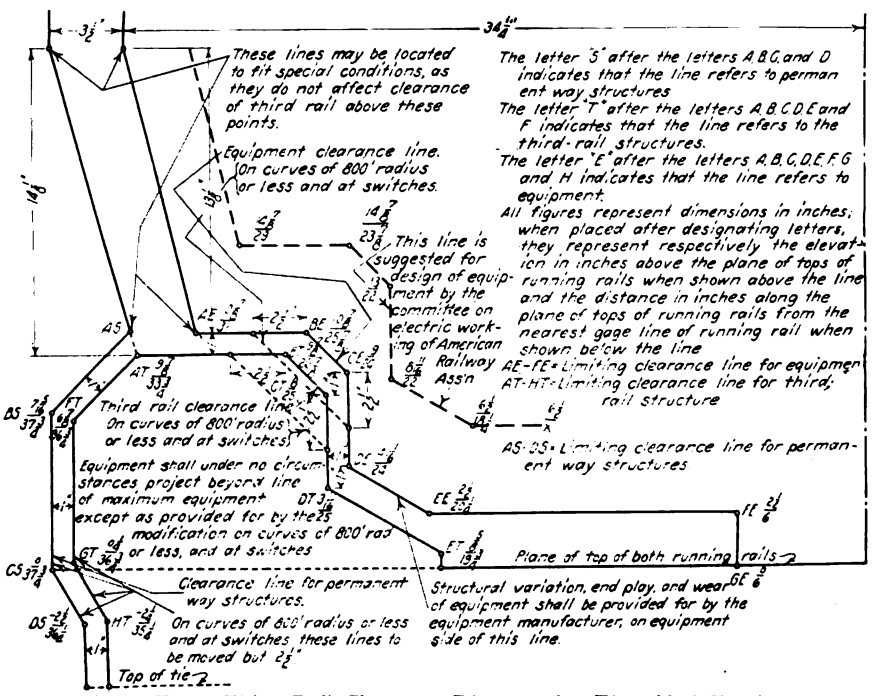
In its recommendation for standard minimum fixed bridge clearance the A. R. E. A. stipulates widths on straight track of 5 ft. 9 in. on each side of the center line of track at a height of 1 ft. above rail top level, and a width of 8 ft. on each side of the center line at heights between 4 ft. and 16 ft. above rail top level, beyond which point the clearance line inclines to a width of 4 ft. on each side of the center line above the top of the rail.

The standard minimum tunnel clearance limits of the A. R. E. A. for straight single track are 8 ft. on each side of the center line from top of rail level to heights of 14 ft., above which points a semicircular arc of 8 ft. radius defines the overhead clearance, its highest point being 22 ft. above the top of the rail. In case the tunnel walls are in yielding material the width of 8 ft. at rail top level may be reduced to 7 ft. to afford a slope of 1 ft. in 14 ft. The contours of double track tunnel clearances outside the center lines of tracks are identical with those of single track tunnels described above, the distance between track centers agreeing with the company's standard, the overhead clearance arc varying accordingly. On curved track these widths are increased so as to provide the same clearance for rolling stock 80 ft. in length, 14 ft. in height and 60 ft. center to center of tracks.

It is common practice to limit the erection of new structures, such as scale houses, signs, etc., to horizontal clearance of 5 ft. or 6 ft. from the grade side of the nearest running rail, as this is a convenient datum line.

The study of track clearances involves the consideration of the salient points of structures of every description which are adjacent to the contours of rolling stock passing over the tracks. The proposed erection of warehouses and other structures adjacent to tracks require the frequent attention of railway employes who are familiar with the standard clearances and with the necessity for considering curvature, super-elevation, the raising of tracks to install ballast or change grades, and such building details as the overhang of eaves of roofs and the necessity for loading platforms at suitable elevations to accommodate car floors and doors.

In the preparation of clearance information it is usual to obtain exact measurements from the center of the track to the nearest points of surrounding fixed structures at right angles to straight track or radially to the center line of curved track. These measurements taken throughout the length of the track on all sides, are plotted, and the points closest to the center line are joined by straight lines to complete the graphic diagram, or the measurements are tabulated.



A. R. E. A. Third Rail Clearance Diagram for Electrified Tracks

It is evident that the two halves of a fixed structure clearance diagram will be symmetrical, each half representing the lines of least clearance for both sides of the track; because, although the clearance lines on the two sides may be unsymmetrical, the moving structures are symmetrical and may move in either direction, even on lines of more than one track. A clearance diagram of all tracks on a division, of a main track on all divisions or any other combination of tracks is readily obtained by a comparison of individual diagrams, and a study of the measurements on each, which are in turn compared with loading diagrams to ascertain what if any alterations are needed in the locations of fixed structures or the dimensions of loadings to provide the necessary margin of safety.

A. R. E. A. Standard Clearances

Railway Bridges

If the alinement is straight, clearances shall be not less than shown on the diagram. If the alinement is curved, the width of the diagram shall be increased so as to provide the same minimum clearances for a car 80 feet long, 14 feet high and 60 feet center to center of trucks, allowance being made for curvature and superelevation of rails. The height of rail shall be assumed as 6 inches.

The width center to center of girders and trusses shall be not less than one-twentieth of the effective span, and not less than is necessary to prevent overturning under the assumed lateral loading.

In skew bridges without ballasted floors, the ends of girders and beams supporting the track shall be square with the track at the abutments.

Wooden tie floors shall be secured to the stringers and shall be proportioned to carry the maximum wheel load, with 100 per cent impact, distributed over three ties, with fiber stress not to exceed 2000 lb. per sq. in. Ties shall be not less than 10 ft. in length. They

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shall be spaced with not more than 6 in. openings, and shall be secured against bunching.

Tunnels

The forms and dimensions of the clear space to be provided for single and for double-track tunnels on tangent should conform to the following diagrams (the height of rail in all cases to be assumed as 6 in.):

The dimensions of the section of tunnels on curved track should be increased and the track placed off the center of tunnel sufficiently to give substantially the clearance given above.

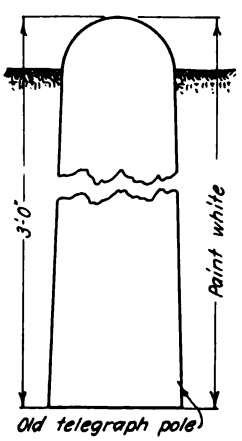
CLEARANCE (Fixed Structure). The limit beyond which adjacent fixed obstacles may not approach the center of track horizontally or the top of rail vertically. Fixed structure clearances are measured horizontally from a line perpendicular to the plane of the tops of the running rails at the center of track and vertically from this plane.

The standard minimum overhead clearance is 22 ft. Minimum side clearances vary from about 7 ft. to 9 ft. and horizontal distances between main track centers vary from 12 ft. to 14 ft. See Clearance.

CLEARANCE (Moving Structure). The limit beyond which railroad rolling stock and loads carried thereon may not extend from the center line of track. Clearances are measured from a line perpendicular to the plane of the tops of the running rails at the center of the track. Loading diagrams of eastern and western lines indicate maximum dimensions of 12 ft. 6 in. to 16 ft. 1 in. in height by 9 ft. 8 in. to 12 ft. in width. See Clearance.

CLEARANCE POINT (Track). The point between two converging tracks beyond which (in the direction of convergence) rolling stock cannot proceed on either track without the probability of striking vehicles on the other track. The standard of minimum clearance between tracks differs on the various railways, ranging from 6 to 9 ft. between the gage lines of the adjacent inside running rails. Clearance points are commonly marked between tracks in switching yards and between passing tracks and main tracks.

Clearance points are variously indicated by a post about 6 in. high, by a timber laid horizontally in the ground at right angles to and between the tracks with one surface or angle showing above the surface, by a sign at one side of the track, by a beveled plank nailed on a cross tie or by a derail.



Standard Clearance Post
A., T. & S. F.

CLEARANCE POST. A marker placed midway between tracks to indicate the clearance point.

The ordinary wooden clearance post is about 4 in. square and 30 in. long with a rounded top painted white, and set in the ground so as to protrude about 8 in. Another type of clearance marker is a timber laid horizontally across the space between tracks with one rounded corner projecting above the ground, eliminating the danger of employes stumbling over it. Another type of clearance marker used on some railways is a sign placed opposite the clearance point at one side of instead of between the tracks. Other railways use a beveled board on which is painted the number of the track, this board being nailed flat on top of the cross tie at the clearance point, and presenting no obstacle to the feet of pedestrians. Clearance markers are necessary only for tracks not provided with derails, which denote the clearance point.

CLIP. See Plate, Clip.

CLIP, ECCENTRIC (Switch). A switch rod clip furnished with a circular eccentrically revolving adjusting device for the purpose of adjusting the throw of the switch.

CLIP, SIDE JAW (Switch). A switch rod clip with a V-shaped plate which fits sidewise onto the switch rod where it is fastened by means of a vertical bolt.

CLIP, TRANSIT (Switch). A switch rod clip drilled with several bolt holes in a line diagonal to the axis of the switch rod for the purpose of adjusting the throw of the switch.

CLOSURE RAIL. A rail in a special track work layout, designed exactly to fill a space between two main parts.

COMBINATION CROSSING (Track). See Switch, Slip.

CONE, VENTILATING. A hollow, truncated cone of sheet metal placed inside a switch lamp over the frame, small end up and attached to the top, while its base is at the level of the tops of the lenses, for the purpose of deflecting down drafts of cold air to the walls, whence they descend to the base, and becoming heated, rise inside the cone and pass out at the top. See Switch Lamp.

CONNECTING ROD, CENTER POINT (Slip Switch). An adjustable steel rod which extends from the bell crank to the No. 1 rod of the center points of a slip switch, by means of which the points are operated from the central switch stand.

CONNECTING ROD, END POINT (Slip Switch). An adjustable steel rod which extends from the bell crank to the No. 1 rod of the end points of a slip switch, by means of which the points are operated from the central switch stand.

CONNECTING ROD, SIGNAL STAND (Slip Switch). A steel throw-rod connecting the signal stand of a slip switch with the reach rod. See Reach Rod (Slip Switch).

CRANE. A weight-moving machine designed for direct lifting and also for horizontal movements which may be circular, radial or universal. A simple crane is composed of an upright mast moving

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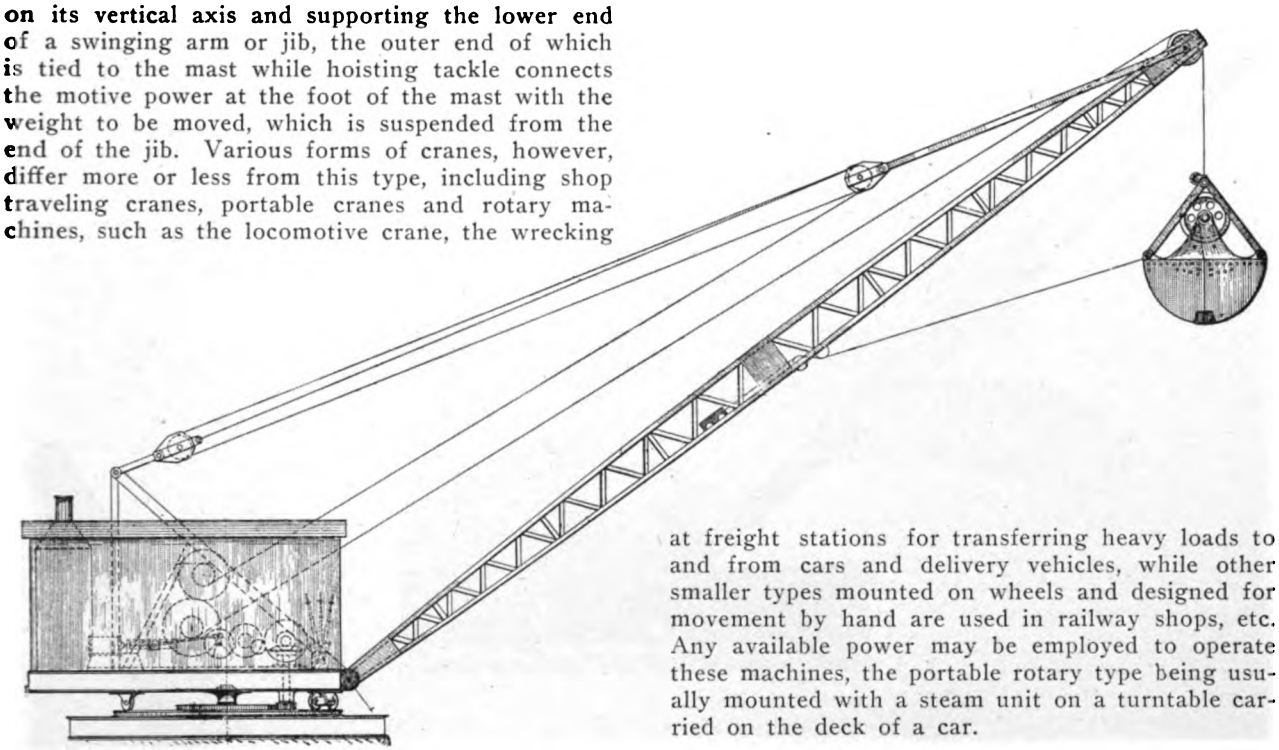
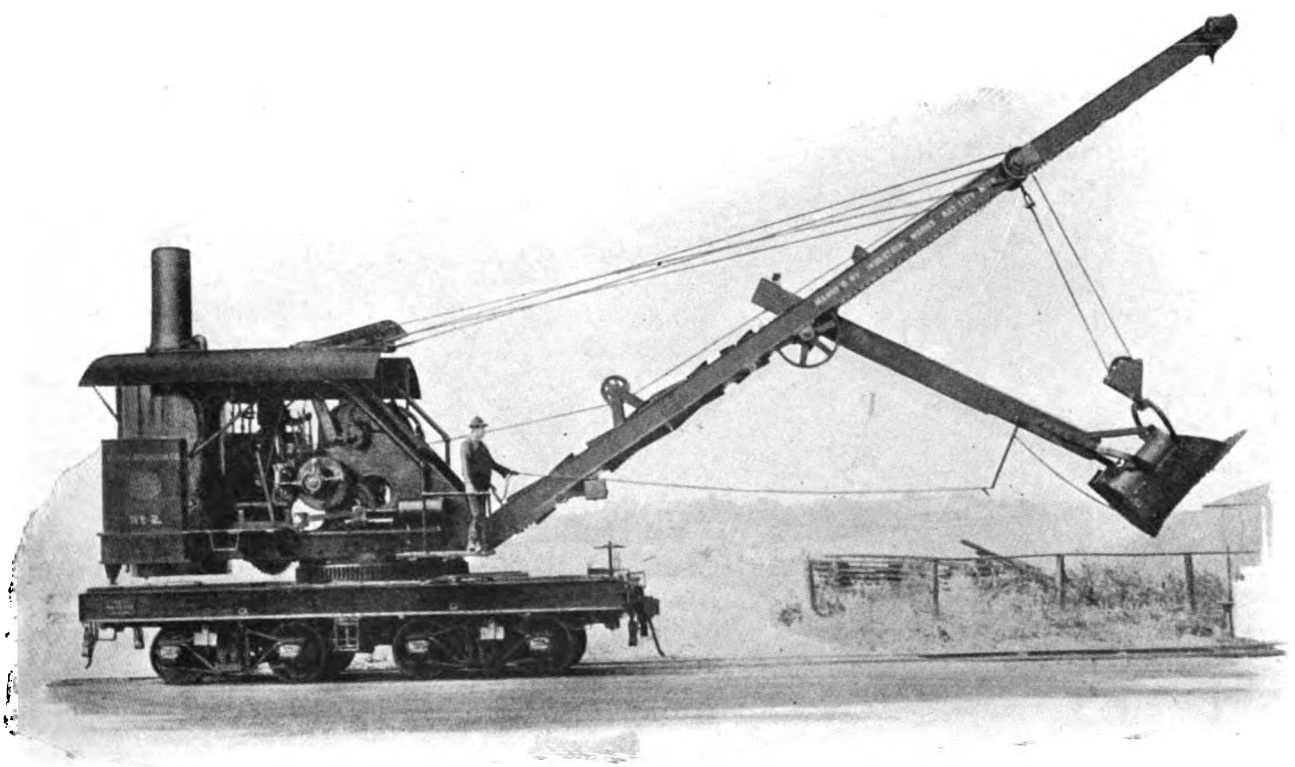
on its vertical axis and supporting the lower end of a swinging arm or jib, the outer end of which is tied to the mast while hoisting tackle connects the motive power at the foot of the mast with the weight to be moved, which is suspended from the end of the jib. Various forms of cranes, however, differ more or less from this type, including shop traveling cranes, portable cranes and rotary machines, such as the locomotive crane, the wrecking derrick, the railway ditcher and the smaller general utility cranes commonly furnished to bridge maintenance forces. Stationary cranes are commonly used at small coaling stations, in material yards and at freight stations for transferring heavy loads to and from cars and delivery vehicles, while other smaller types mounted on wheels and designed for movement by hand are used in railway shops, etc. Any available power may be employed to operate these machines, the portable rotary type being usually mounted with a steam unit on a turntable carried on the deck of a car.



Full Circle Crane
The Edw. I. Terry Manufacturing Co.

CRANE, LOCOMOTIVE. A revolving, self-propelling, long boomed, general utility crane designed to handle a grab bucket, lifting hooks or magnet to move coal for locomotive use, to handle track materials, coal, cinders, earth or scrap steel, to erect bridges and excavate foundations, etc.



Industrial Crane Equipped with Dipper Arm
The Industrial Works

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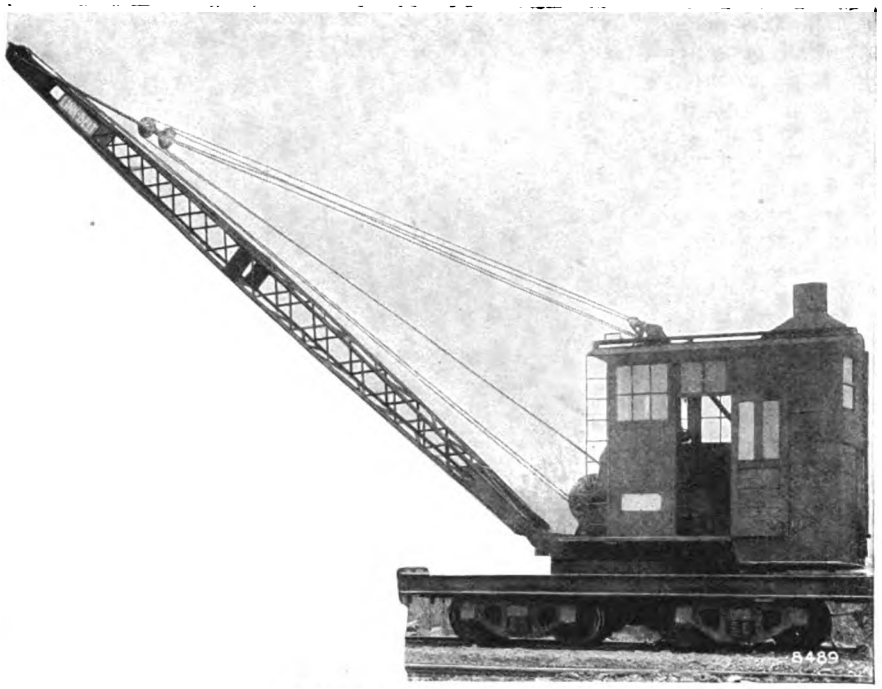
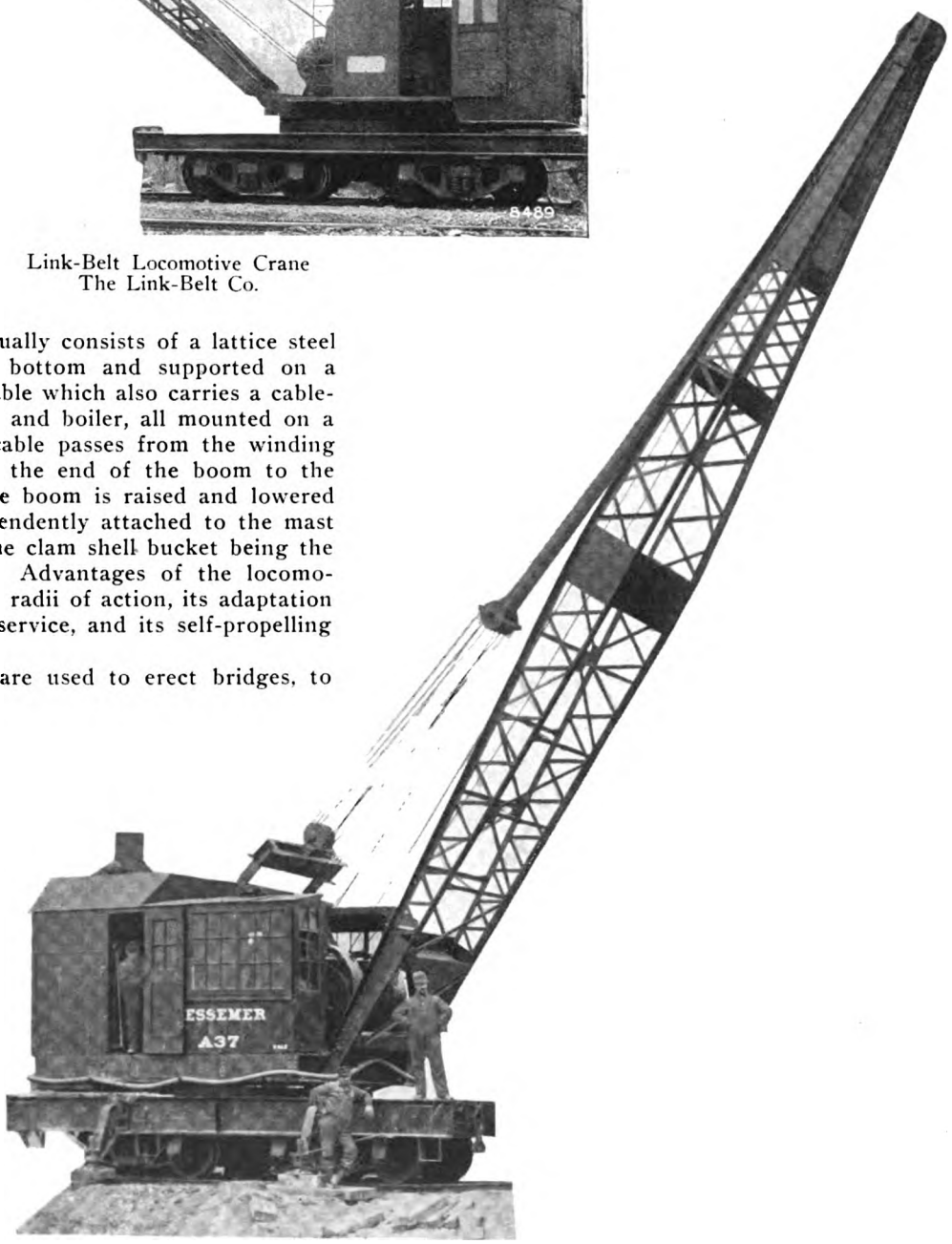


Link-Belt Locomotive Crane
The Link-Belt Co.

This type of crane usually consists of a lattice steel boom hinged at the bottom and supported on a horizontal steel turntable which also carries a cable-winding drum, engine and boiler, all mounted on a car. The operating cable passes from the winding drum over pulleys at the end of the boom to the grab bucket, while the boom is raised and lowered by another line independently attached to the mast and operating gear, the clam shell bucket being the usual loading device. Advantages of the locomotive crane are its wide radii of action, its adaptation to various classes of service, and its self-propelling features.

Locomotive cranes are used to erect bridges, to



Locomotive Crane
The McMyler Interstate Co.
(See Page 745)

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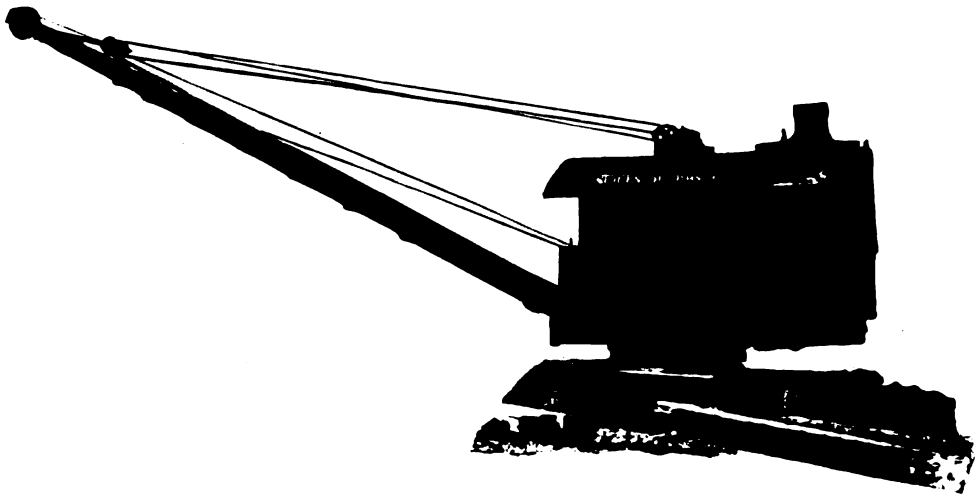
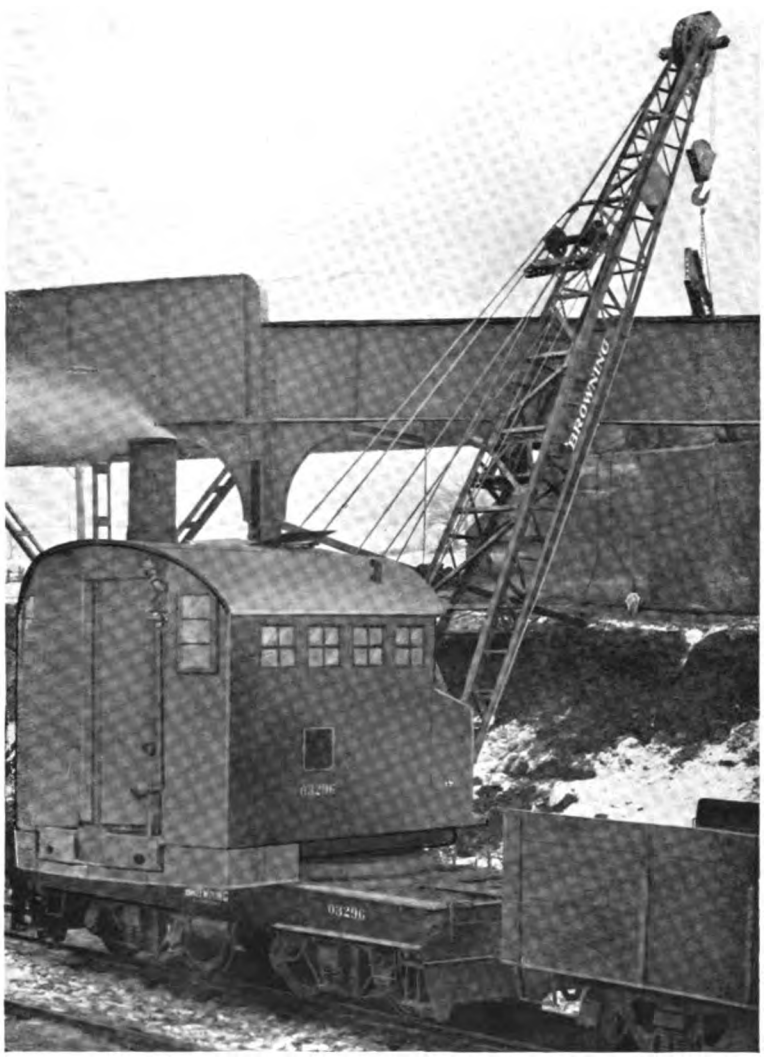


Locomotive Crane
The American Hoist & Derrick Co.
(See Page 634)



Locomotive Crane
The Browning Co.

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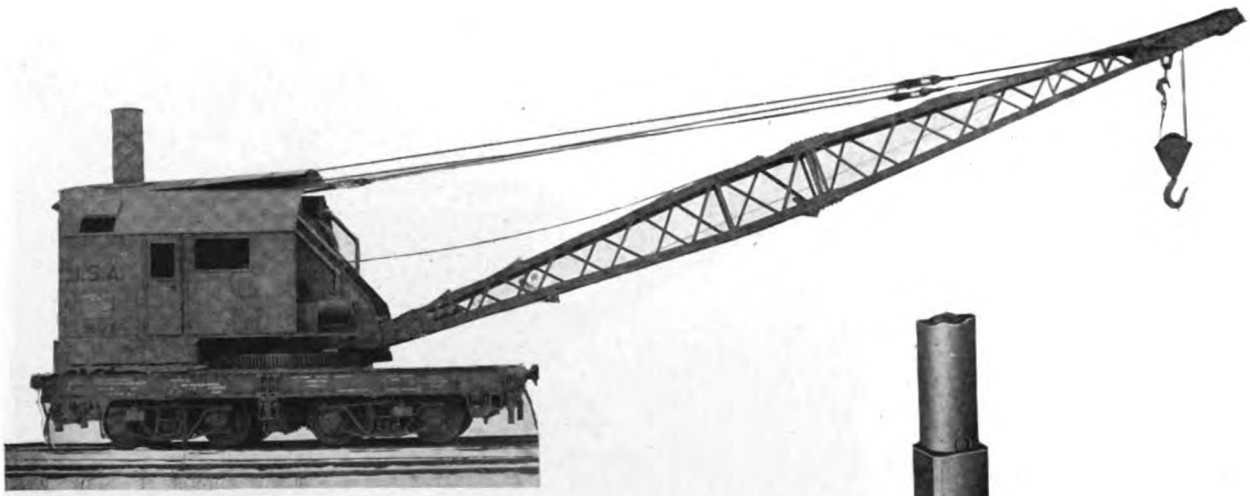
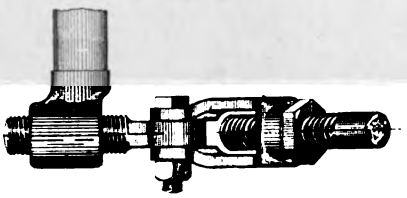


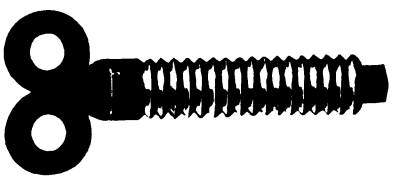
Locomotive Crane
The Industrial Works

relay track and to handle many kinds of heavy materials. See Crane.

CRANK, ADJUSTABLE (Switch). A switch operating device by which the position of the mechanism at the base of the spindle may be altered to adjust the throw of the switch, as a threaded



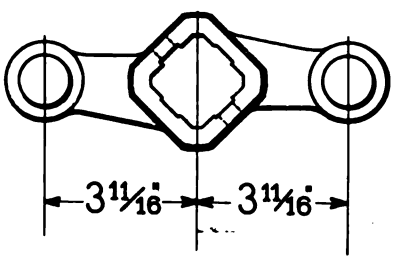
Adjustable Switch Stand Crank
The Ramapo Iron Works
(See Page 784)



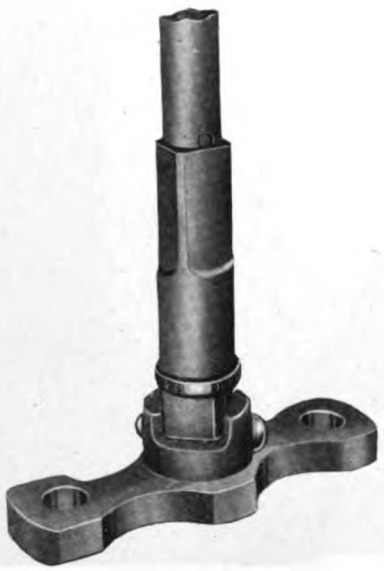
Double Eye Adjustable Crank Pin
The Buda Co.
(See Page 660)

eye-bolt attached to the bottom of the spindle and fitted to a threaded socket on the end of the connecting rod. See Switch Stand.

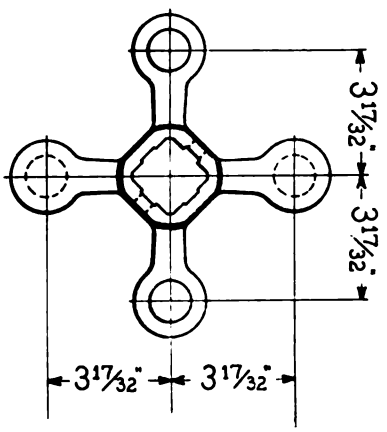
CRANK, BREAKABLE (Switch). A short crank casting of soft metal designed to break when the



Two-Way Switch Crank
The Pettibone Mulliken Co.



Breakable Crank
The Morden Frog and Crossing Works.



Breakable Switch Stand Crank
The Pettibone Mulliken Co.

switch is run through and so prevent injury to the switch point rails. See Switch Stand.

CROSSING, TRACK. See Track Crossing. Also Frog.

CROSS-OVER, DIAMOND. See Cross-over, Double.

CROSS-OVER, DOUBLE. A track arrangement which permits trains proceeding over a parent track in either direction to cross to another or parallel parent track. A double cross-over may be placed

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in tandem or the switch points of the two cross-over tracks may be opposite, in which case a track crossing is necessary where the two cross-over tracks cross each other between the parent tracks.

CROSS-OVER TRACK. A connection for trains to pass from one track to another, as the parallel main tracks of a double track line. The cross-over consists of two turnouts, one in each parent track and facing in opposite directions, with a section of track connecting the turnouts between the heels of the frogs. Cross-overs may also connect tracks not parallel and at any distance apart.

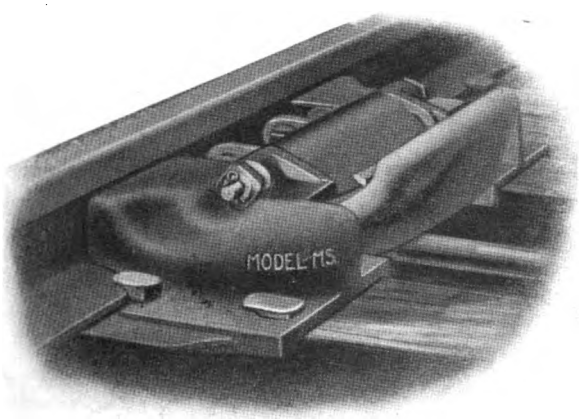
CROTCH TURNOUT. A turnout in which a crotch frog is used. It is required either in a turn-out between two tracks which curve in opposite directions or in a three-way turnout in which the middle frog is at the crotch.

CRUSHED HEAD (Rail). A flattening of the crown of a rail, usually accompanied by crushing of the head and a dark streak in the bright surface metal indicating loss of contact with wheel treads.

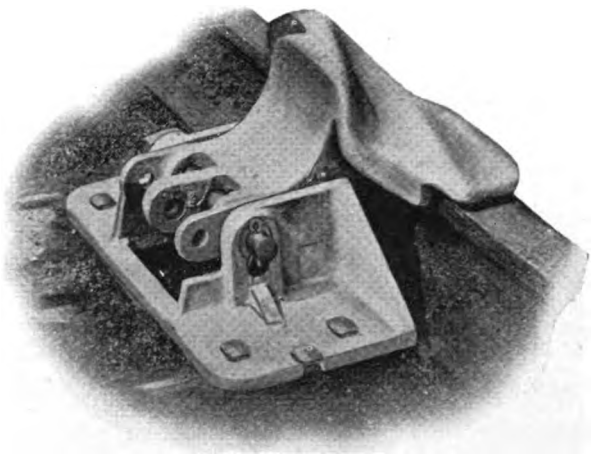
D

DERAIL. A track safety device designed to guide railway rolling stock off the rails at a selected spot as a means of protection against collisions or

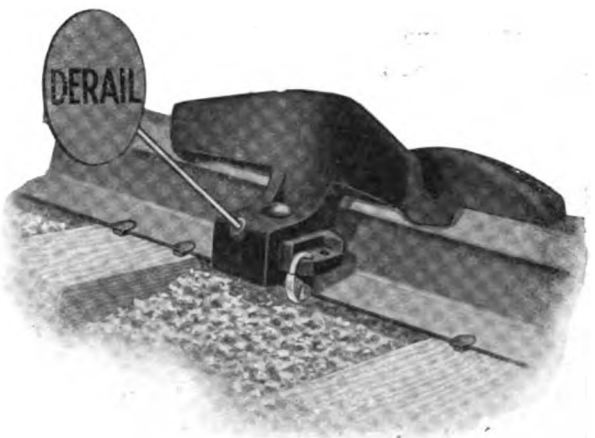
Superior Derailer
The Track Specialties Co.
(See Page 817)



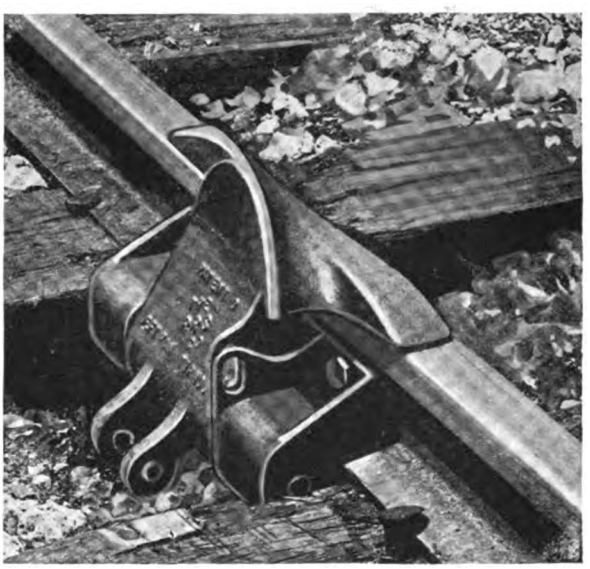
Freeland Derail
The Q & C Co.
(See Page 777)



Double Hand Derail
The Q & C Co.
(See Page 777)



Portable Derail
The Q & C Co.
(See Page 777)



Chicago Derail
The Railroad Supply Co.

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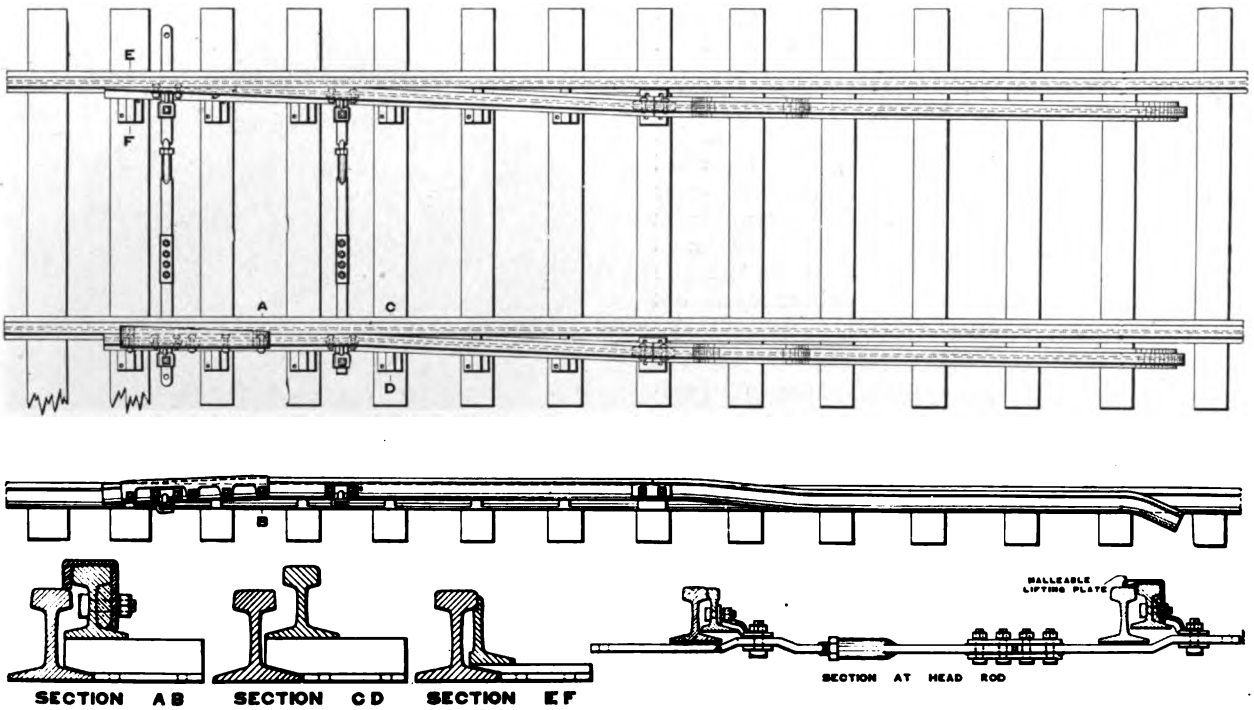
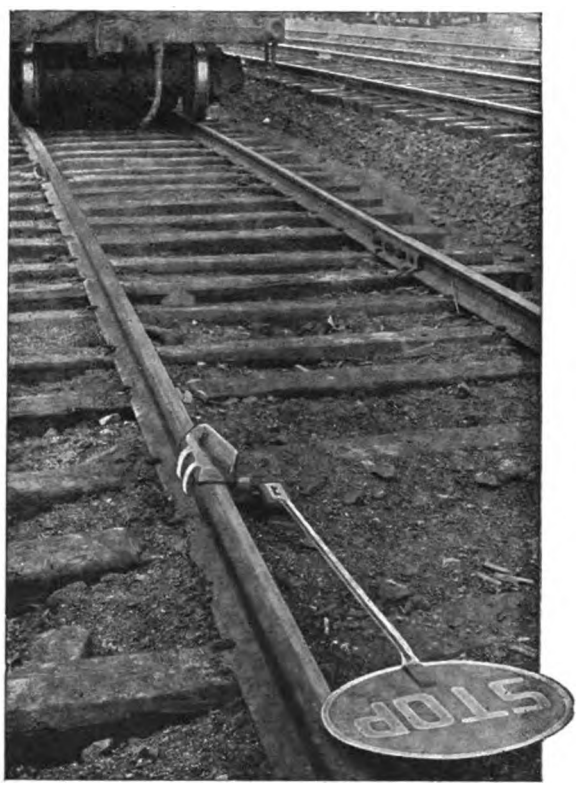
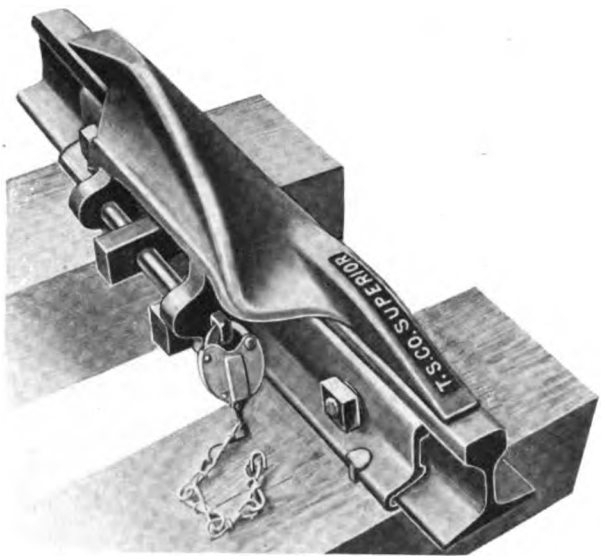


Lifting Derail with Malleable Lifting Plate
The Morden Frog & Crossing Works



Reading Safety Derail with Stop Sign Lowered
The Reading Specialties Co.
(See Page 787)



Hand Throw Derail
The Track Specialties Co.
(See Page 817)

other accidents. Derails are commonly used on turnouts to prevent cars from fouling the main or parent track and at interlocked railroad crossings to prevent collisions on the crossings.

The development of derailing devices has proceeded from the stub switch to the split switch

Hayes Derail
The Hayes Track Appliance Co.
(See Page 704)

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types and thence to lifting derails and castings which may be placed on the rail and displaced without interfering with the continuity of the track. Derails generally may be arranged to be operated either by hand, by the use of an adjacent switch stand, by pipe-connection to the switch stand of the turnout or by other switch mechanism.

The stub switch derail is an adaptation of a single stub switch rail to one line of running rails, the movement of the free end of the derail being controlled by a connecting rod from a switch stand or some other operating mechanism, and the limit of movement being about 4 in., usually on a sheet-steel slide plate. These derails are inexpensive and easy to install and operate but tend to bind at the free end when the rails creep, while such a considerable element of danger is involved in running trains over the unspiked short rail that the type is now practically obsolete. The split switch derail, similarly operated, is made from a single split switch point rail. This type is favored especially for use at interlocking plants because it breaks the continuity of the line of rail when in the closed position.

The lifting derail is a section of T-rail about 6 ft. long placed parallel and adjacent to the running rail but bent upward and outward to lift and carry the wheels off the track. It is operated sidewise to open as is the split switch type, and is likewise in common use at interlocked switches.

A hinged derail consists of a casting with top surfaces slightly inclined, or an arched bar of steel about 5 ft. long, tapering from its middle towards the beveled ends. This device is hinged to a side rod or to the web of the running rail and is designed to rest on the top of the rail of a protected track so as to throw the flanges of wheels, as they mount the derail, diagonally over the top, dropping them on the ties outside the track without injury to the rails.

The sliding derail is a casting 3 or 4 in. high in the center, tapering to the ends and integral with a cross member which slides back or forth in a fixed side sleeve so as to place or withdraw the derailing casting which has inclined and ridged surfaces so fashioned as to throw the flanges of car wheels off the rails.

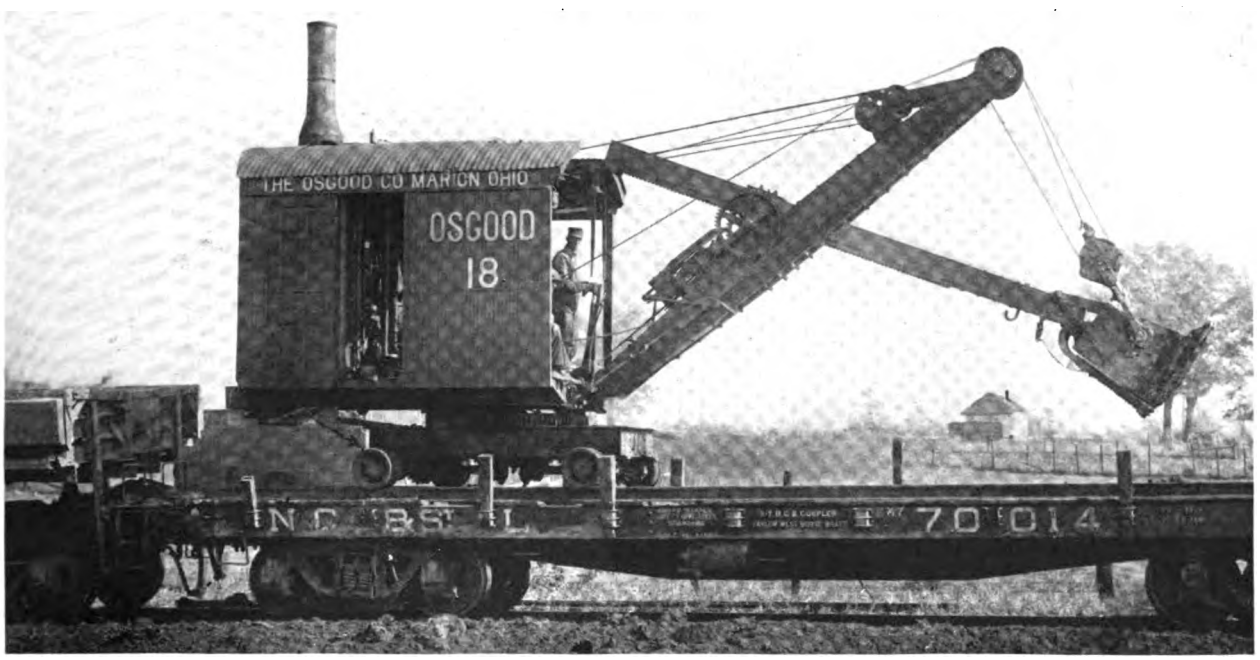
DIGGER, POST HOLE, CYLINDRICAL. A tool for digging holes in soil for posts, etc.

The style of digger commonly used in hard ground consists of a cylindrical steel band or blade about ¼ in. thick and 8 in. high sharpened on the lower circular edge, opened along one side and fastened to a top casting or bracket which is united at its top to the rod which forms the handle. This tool is operated by forcing the blade into the ground with a downward thrust, the material clinging in a solid mass to the inside of the cylindrical blade until dislodged by striking the vertical edge.

DIGGER, POST HOLE (Scissors). A double-bladed tool for digging holes in the soil for posts, etc.

This device consists of a pair of cross-handled, round-pointed, segmental steel blades about 9 in. long, with integral, bolt-hinged shoulders ending in twin handle sockets, which hold the butts of 50 in. wooden handles. The spades set with the corresponding edges of their opposite inside concave faces about 2 in. apart when the handles are close together and parallel. With the parts in this position, the tool is designed to be thrust into the ground to cut a round hole, confining a cylinder of earth between the spades. When the handles are spread, the ends of the blades tend to close together, compressing the cylinder of material to a cone-shape, when it may be lifted readily.

DITCHER. A revolving type of self-propelled steam shovel pivoted on a geared turntable mounted on a frame usually carried on a standard car frame and trucks or sometimes on four small solid double



Railway Ditcher
The Osgood Co.
(See Page 763)

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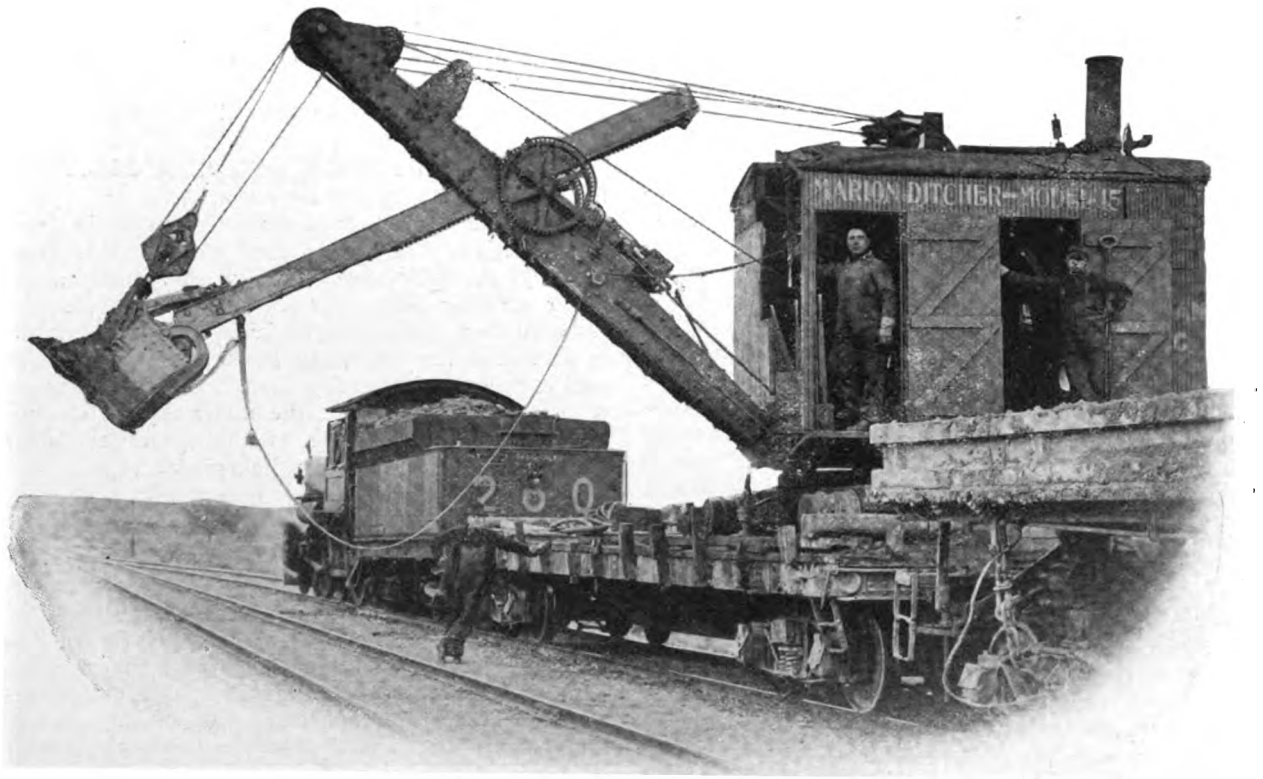
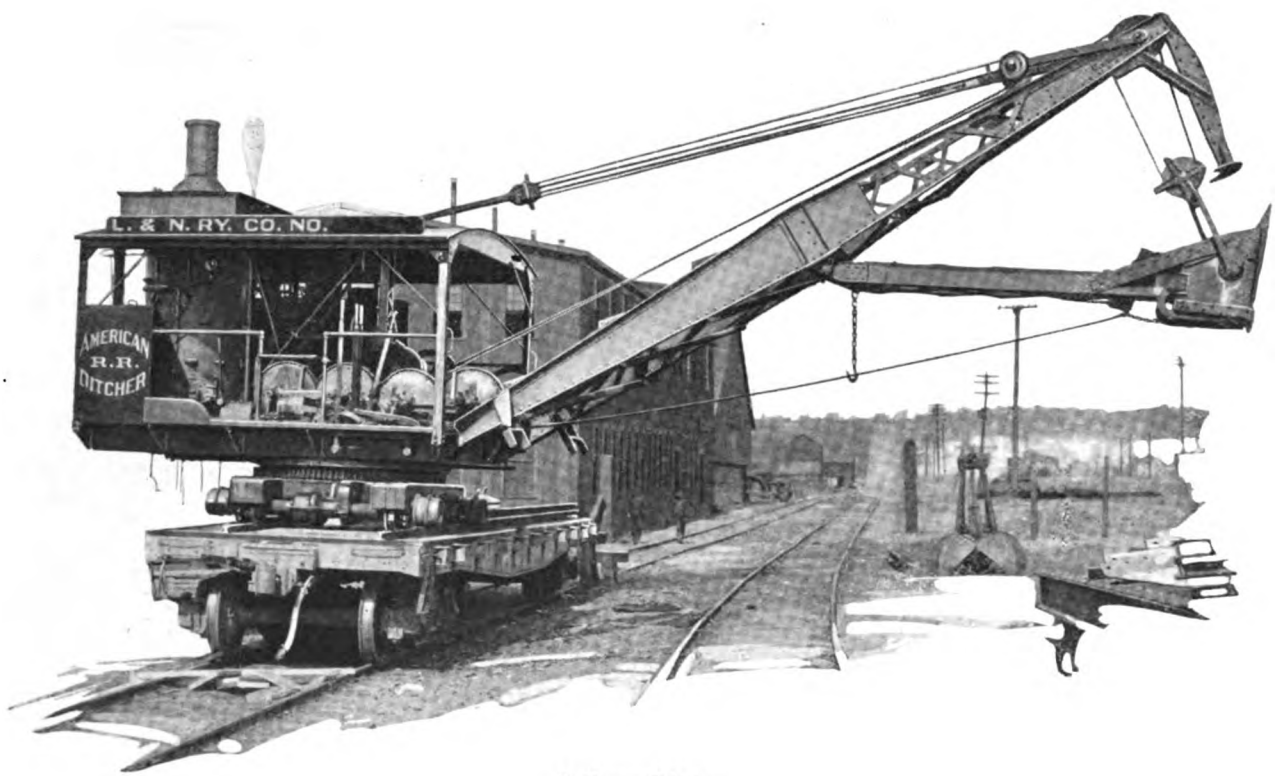


Railway Ditcher
The Marion Steam Shovel Co.
(See Page 746)



Railway Ditcher
The American Hoist & Derrick Co.
(See Page 634)

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Erie Railway Ditcher
The Ball Engine Co.
(See Page 655)

flanged wheels made to run on lapped sections of double gage track laid loosely on ballast car floors; primarily designed to excavate side ditches in railway cuts, and to load the materials into cars between which it is coupled or on the cars over which it travels.

The machine travels by means of beveled gears, usually connected from the drum shaft down through the revolving center to the drive axle. Throttle levers located in the cab control the swinging, digging and hoisting motions as well as the movement of the ditcher over the flat cars, each motion being controlled independently. The horizontal turntable allows for a complete revolution of the ditcher, thus making it possible to excavate and deposit material at any horizontal angle. The dipper arm, which terminates in a steel dipper of an average capacity of about 1 cu. yd., is either centrally hinged to the boom and operated by means of a cable passing over a pulley at the end of the boom and fastened to the bale of the dipper or it is designed to extend through and between the parallel boom members near their middle by means of a cross gear which engages a straight, wide ratchet several feet long fastened on the bottom surface of the dipper arm; or the dipper arm may have two parallel members between which the boom extends. The steel dipper is almost cubical in form, its flat door being hinged, latched and designed to fall open to discharge the load by gravity when the dipper is raised and the latch tripped.

The ditcher differs from the railroad type of steam shovel in that its movement is circular instead of radial, which enhances the mobility afforded by the geared turntable, the compact arrangement of levers and the light weight of the machine which adapt it to operation with the various types of open top cars. It can also be rigged to do general hoisting, to handle grab buckets, to drive piles, etc. A special feature of this machine is its comparative rapidity of action. See Steam Shovel (General Section).

DRAIN, FRENCH. An underground passageway for water through the interstices among stones placed loosely in a trench.

The largest boulders usually are thrown into the bottom of the trench, the sizes of the stones dimin-

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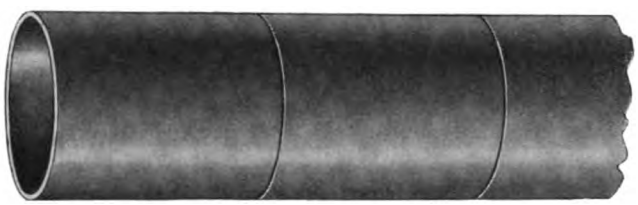
ishing toward the top which is covered with fine material such as gravel or cinders. French drains are economical in first cost and in firm ground they frequently last for a number of years, silt gradually diminishing the water carrying capacity. They are commonly made 2 ft. 6 in. deep or deeper, the areas of long drains increasing from the source towards the outlet when laid in long railway cuts where the water is accumulated throughout the length of the drain, from the run off of the road bed and slopes. French drains are especially adaptable to cross draining road beds and for side ditches in comparatively short cuts and in other locations where surface drains are not desirable and where the soil is of sufficient firmness to leave a clear passageway between the stones.

DRAIN, ROADWAY. An artificial waterway designed to conduct water away from the tracks. These devices may be located with a view to carrying either surface water or subsoil drainage, the usual types being (1) open surface ditches, sometimes carried across the roadbed in troughs or coverless boxes, and (2) underground tile drains, or stone filled trenches generally known as French drains.

The function of a roadway drain is to intercept water before it reaches the roadway and to lead it into the nearest channel which will carry it to the downstream side of the grade without damage; or to



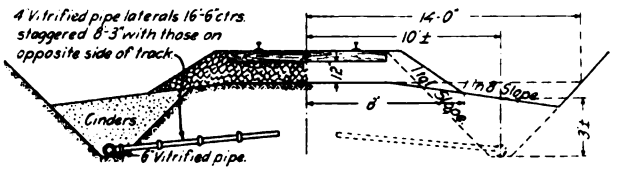
Tile Drain

lead away water which has accumulated in or on the upstream side of the roadway. The influence of these drains is local and their carrying capacity is relatively small, surface ditches commonly having minimum cross sectional areas of 2 sq. ft. to 2½ sq. ft., while drain tile is less than 24 in. in diameter, the farm tile used for draining ditches in cuts averaging 4 in. to 8 in. in diameter. French drains are made of suitable extent for individual cases, but they rarely have carrying capacities equal to that of a circular drainage culvert 24 in. in diameter.

Surface Ditches

While open ditches are universally used for local surface drainage of many sorts, they are considered indispensable at the tops of certain cuts where the natural slope of the ground is toward the track. The surface ditch extending in a line approximately parallel with the top of the slope, intercepts the surface water and conducts it to points beyond the ends of the cut where it is turned away from the roadway or led directly to the first waterway under the track. Such disposition of surface water tends to minimize the erosion of the slopes of cuts and to prevent the carrying down of mud and water on the tracks and the consequent damage to the roadbed, which is further protected by surface ditches at the toes of the slopes to carry water to the ends of the cut for disposal. Where it is desirable to drain borrow pits, they are connected by surface ditches, but if such a current of water is undesirable alongside the embankment the borrow pits are separated during construction, the natural ground being carefully maintained between their ends.

Swamps are preferably drained before the grade is made, the surface ditches being dug while clearing and grubbing is in progress to allow the spongy

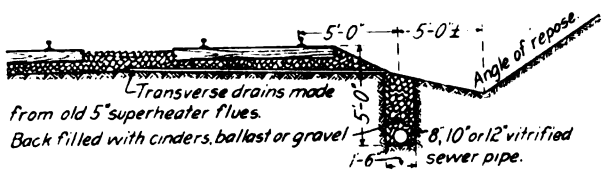


Transverse Road Bed Drain of Earthenware Pipe

vegetable matter of the soil to dry, when the material is handled readily.

Improvement in the drainage of track across swamps can sometimes be made by placing box drains between the ties at short intervals, with their tops at subgrade level, to carry the water through before it rises on one side of the grade and overflows the roadbed, as it sometimes does, owing to the peculiar topography of the land surrounding the swamp. Sometimes a search around the rim of the swamp will reveal the lowest ground where a short ditch may form an outlet which will effectively drain the whole basin and leave the track high and dry. Such searches are good practice and sometimes result in reducing maintenance work on long stretches of track at a nominal cost for ditching. If the search shows a prospect of extensive ditching a survey is usually advisable, as many promising drainage projects prove impracticable when tested with a level.

Railway embankments sometimes develop water pockets, usually on account of imperfect construc-



Transverse and Longitudinal Road Bed Drains

Underground Drains

tion. A slight depression in a roadbed where water accumulates, tends to gradually deepen and widen as ballast is added from time to time to maintain the track in the proper surface. Roadway drains to remedy such conditions are laid below the bottom of the pocket. While iron pipes are in some cases driven into the embankment from the slopes, the more usual and surer method of drainage is to dig trenches at right angles to the track from the slopes toward the center line and low enough to drain the bottom of the water pocket, when drain tile of suitable capacity, laid on a board trough to maintain its line and surface at the bottom of the trench, is

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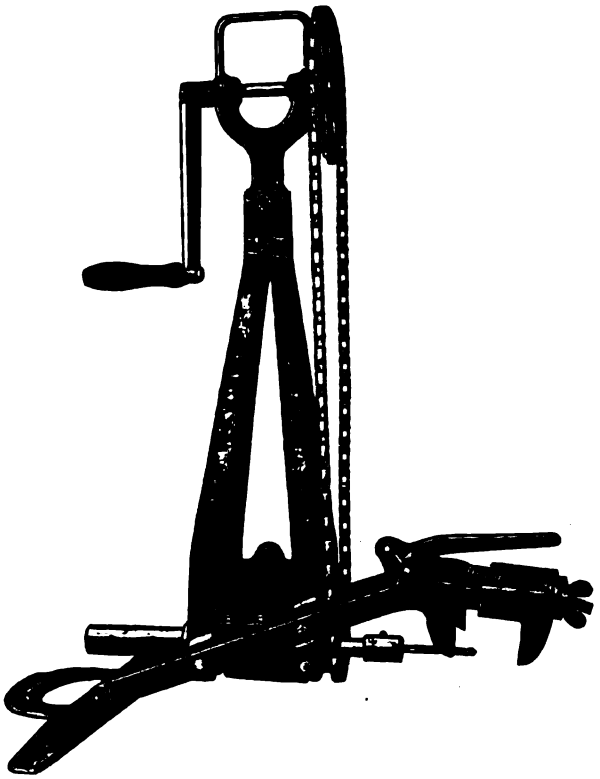
installed and covered first with a layer of cinders or gravel from 12 in. to 24 in. deep, the trench then being refilled with dry earth, gravel or sand. Sometimes the trench is filled with a layer of large stone two or three feet deep which is covered with smaller stones and gravel in successive layers to fill the trench. Such a seepage trench is called a French drain. They are most effective when new, tending to become obstructed gradually with small particles of stone and earth.

Roadway drains are frequently ineffective on account of neglect. Inlet and outlet pipes may be crushed and filled with earth or overgrown with weeds, choked with leaves or buried in snow, unless systematic work is done periodically as well as in times of emergency to keep them in good condition. It is considered good practice to install roadway drains at frequent intervals to dispose of water quickly, rather than to conduct it for long distances along the upper side of the roadway before carrying it under the track. See Culvert (Bridge Section).

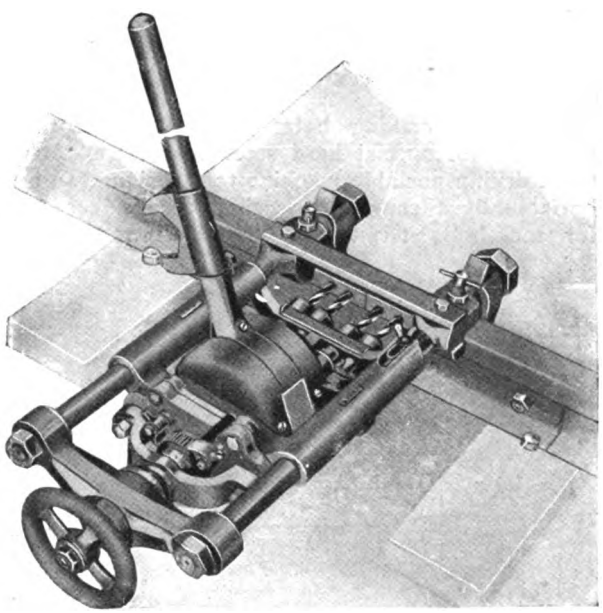
DRAIN TILE, EARTHENWARE. A short, hollow, cylindrical pipe of burned clay designed to be laid end to end to form a drain for surface water, etc. This type of pipe is made by pressing moist prepared clay through a molding machine or other device which automatically cuts it into uniform sections as it is pressed from the cylinder. The clay product, after thorough air curing, is heated in ovens until burnt to a red hardness.

There are three classes of tile: farm drain tile, standard drain tile and extra-quality drain tile, the standard type being most commonly used for railway purposes. It is generally manufactured without bells and is laid end to end to form butt joints through which water may enter. Unglazed drain tile is slightly absorbent and of only medium strength and is therefore suitable only in places where it is not exposed to frost or to severe intermittent exterior pressure and where drainage is desired for a continuous flow of water. Experiments have shown that only about five per cent of the water which flows through unglazed tile enters through the porous walls, while 95 per cent enters at the open joints. Drain tile should be placed well below the frost line to protect it from deterioration due to freezing. Its efficiency depends also on the care with which it is laid and covered. The ends should touch and be in line to prevent dirt from clogging the passageway. The foundation should be smooth and hard. When as is usual the drain is in yielding ground, it is good practice to lay the tile on a bed of cinders or in a shallow board trough to obtain regularity of grade and to prevent the sinking of individual tiles, thereby destroying the continuity of the line of pipe. The practice of covering the tile with grass is deprecated because the grass clogs the joints gradually. It is better to cover the tile with coarse gravel or stone on which finer porous material is placed, preferably gravel or cinders, either of which forms good filling, which should extend to the surface. To be efficient any such drain must be laid well below the bottom of the stratum to be drained. A line of standard tile from 4 in. to 8 in. in diameter laid in a narrow trench about 3 ft. deep on either side of the roadbed (sometimes connected by cross drains) and covered with cinders and loose rock usually forms an effectual railway roadbed drain. See Pipe (Culvert) (Bridge Section).

DRILL, BONDING. A portable machine drill especially for drilling holes in the webs of rails in track for the insertion of metal pins to hold the bond wires which connect the ends of rails to insure the electric continuity of track circuits.



Bonding Drill
The Chicago Railway Signal & Supply Co.



Four Hole Bonding Drill
The American Steel & Wire Co.

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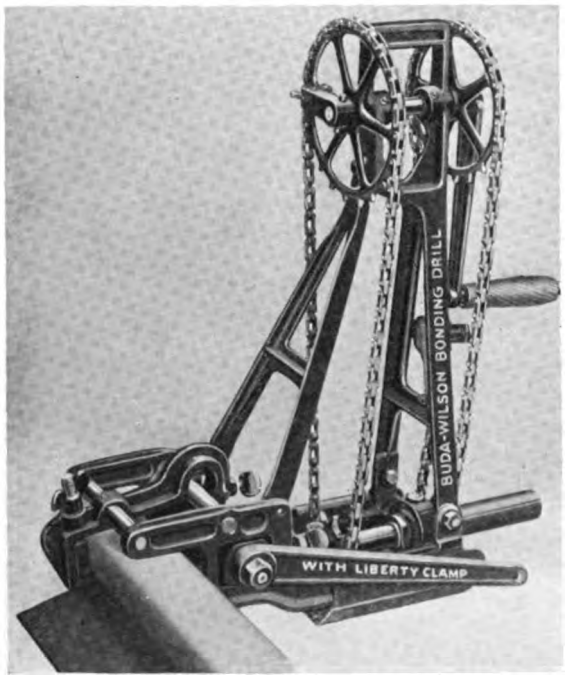
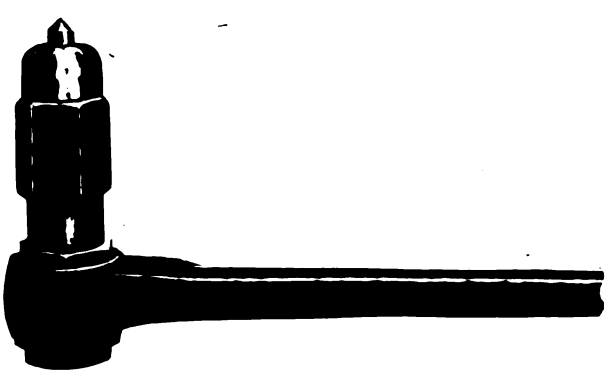


Buda-Wilson Bonding Drill
The Buda Co.
(See Page 659)

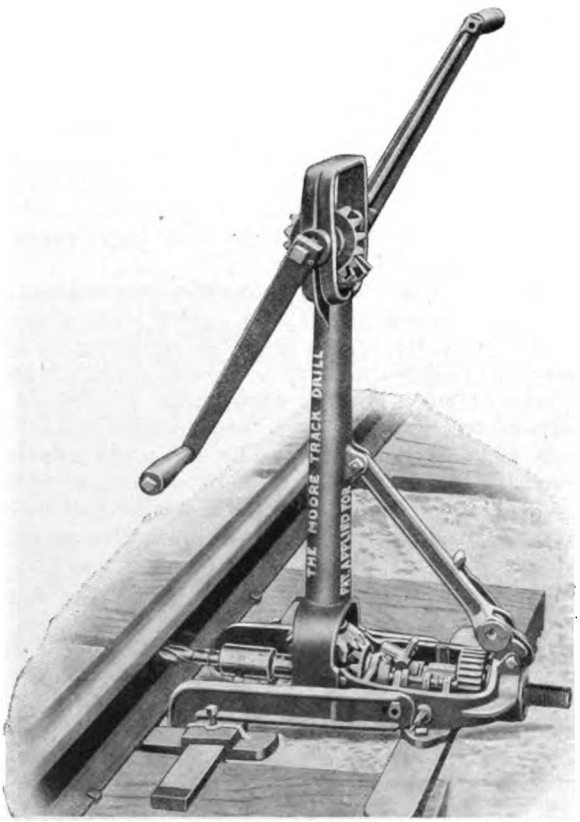
A similar portable chain gear machine is used to drill holes in the webs of rails for bond wire pins. This lighter machine commonly has only crank handle on the horizontal spindle at the top of the frame. At the ends of the spindle are two opposite sprocket wheels (one being a drive sprocket and the other a feed sprocket) over which endless chains extend, engaging and turning the smaller sprocket wheels on the bottom spindle which holds and rotates the chuck and drill-bit.

DRILL, TRACK. A machine tool designed to operate horizontally to drill holes through the webs of track rails, especially for track bolts. It may be a one-man ratchet drill or a geared drill machine with a frame, rail clamps, feed screw, high speed steel bit and chuck and alternating crank handles turned by two drill men.

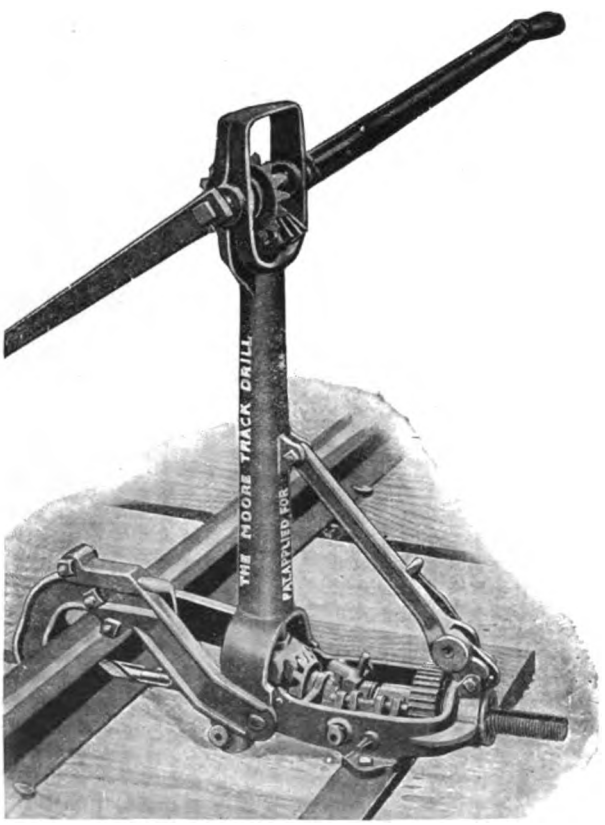
Drills for making holes in steel are rotating machines for special hard steel boring tools. The track drill, a portable machine tool designed to bore horizontally through the webs of rails, especially for track bolts at rail joints, is made in two all-steel



Ratchet Track Drill
The Keystone Manufacturing Co.



Underclutch Moore Track Drill
The Kalamazoo Railway Supply Co.
(See Page 728)



Overclutch Moore Track Drill
The Kalamazoo Railway Supply Co.
(See Page 728)

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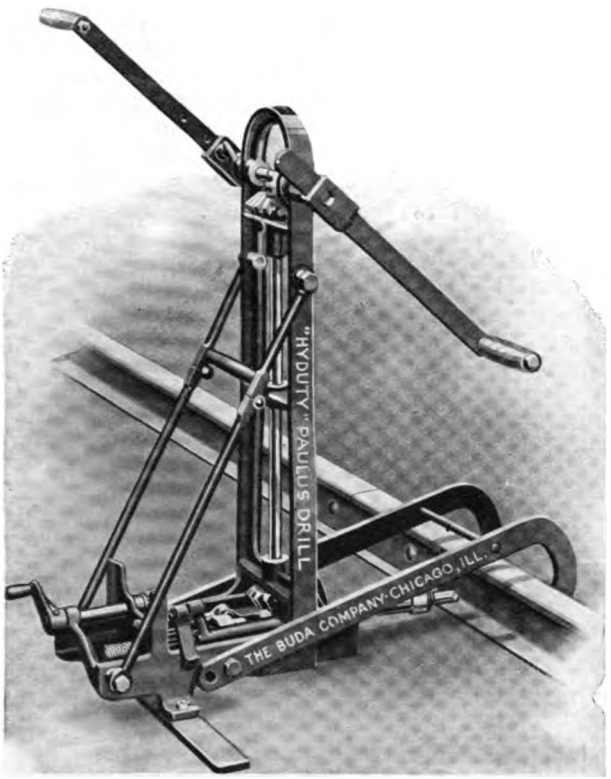
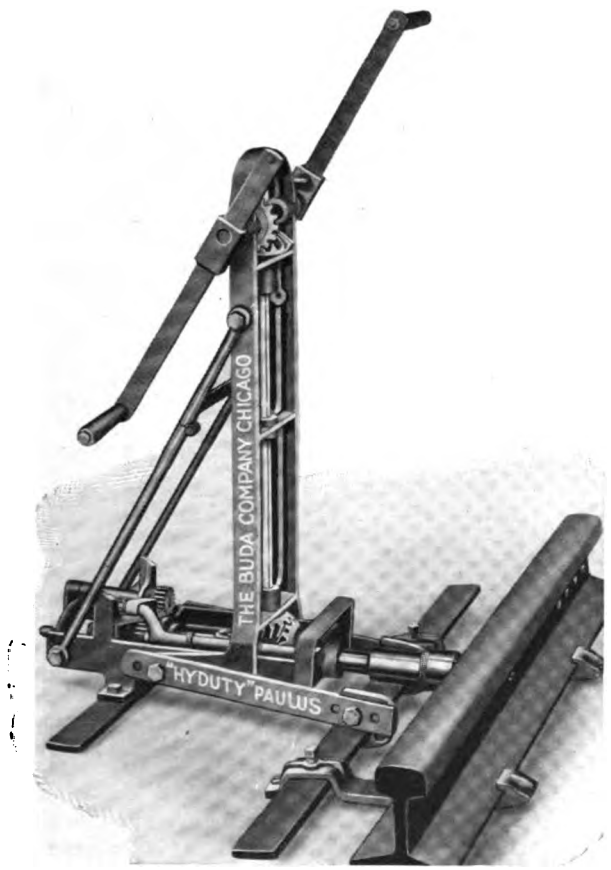


Overclutch Hyduty Paulus Track Drill
The Buda Co.
(See Page 659)

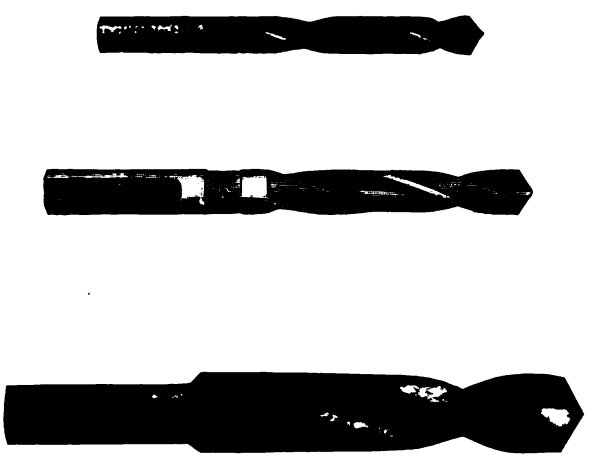


Underclutch Hyduty Paulus Track Drill
The Buda Co.
(See Page 659)

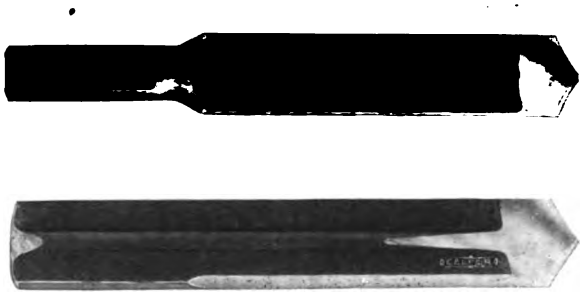
types, the one-man ratchet drill and the higher speed, double-crank bevel-geared machine, with fastenings to clamp it either to the foot or the head of the rail. The tubular ratchet drill with its long steel cross handle resembles a hammer. The drill head is operated horizontally between the rail to be drilled and a special clamp, or frequently a piece of rail temporarily spiked on the tie to hold the drill against the work. The drill head, being thus held endwise against the web of the rail, is rotated by means of an 18-in. to 24-in. ratchet handle which revolves in a vertical plane at right angles to the plane of the bit.

The larger bevel gear track drill operates a drilling tool in the plane of the horizontal skeleton base on which is erected a diagonally-braced vertical U-frame about 30 in. high, holding a central shaft geared at each end, the top bevel gear engaging the gear of a horizontal spindle to the end of which the alternating crank handles are attached; while the bottom bevel gear is similarly meshed with and rotates the bit stock, the bit being pressed against the web of the rail by means of an adjusting screw at the back of the base. The frame is hinged to raise or drop readily without displacing the drill from the work, this feature permitting the drilling to be done with a minimum of interruption by passing trains.

DRILL BIT, TRACK. A steel boring tool used by attachment to a track drill; specifically a short, hardened steel, straight or twisted, bevel-pointed shaft about 6 in. long, fastened to and rotated by the drill for the purpose of boring track-bolt holes



Three Common Types of Twist Drill Bits



Two Common Types of Straight Drill Bits

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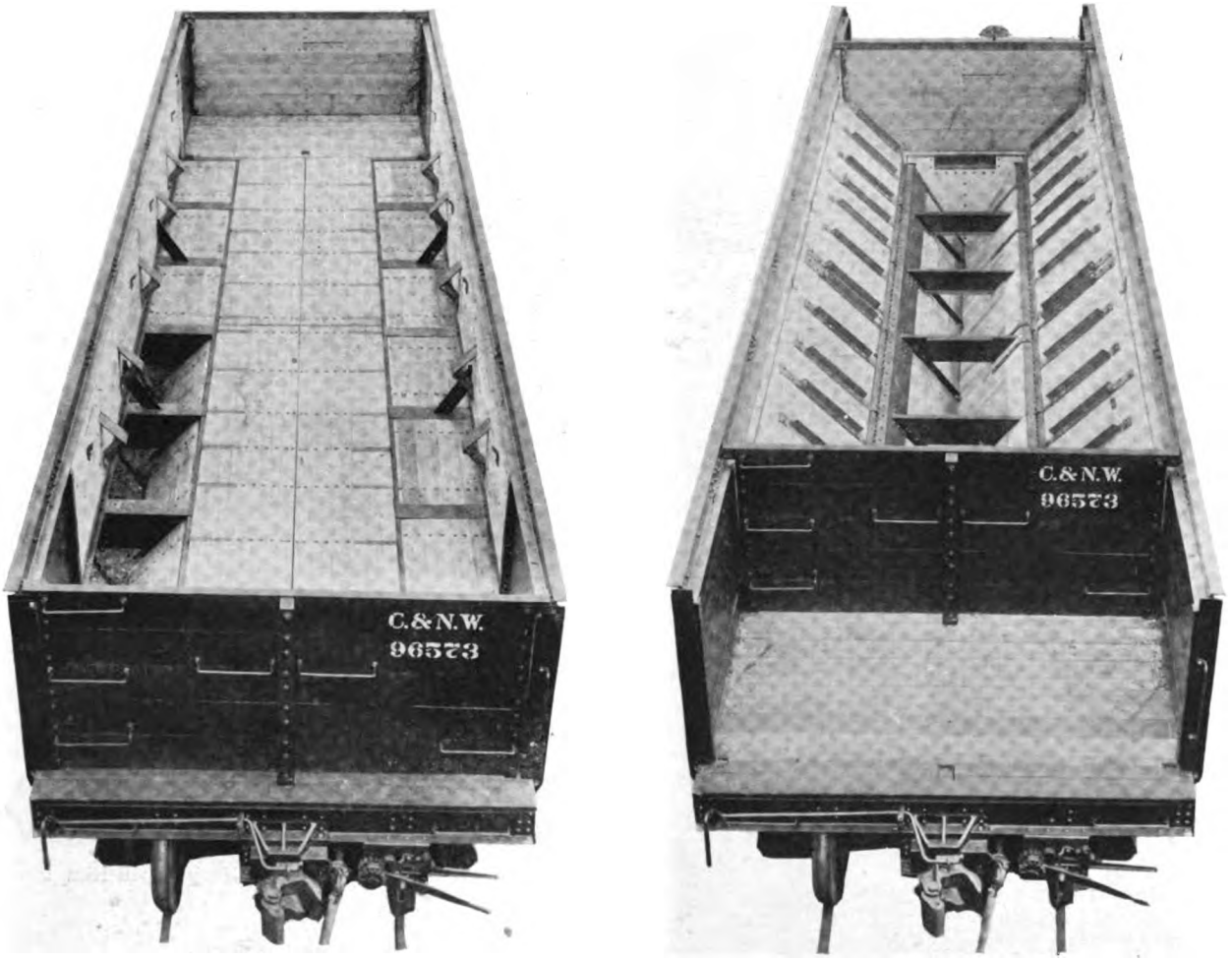
through the webs of rails. The straight bit is usually of flat or ribbed steel about ½ in. thick and from ¾ in. to 1¼ in. wide with a ¾ in. shank, the tool being about 6 in. long over all. The twist drill differs in having a wide-lipped, spiralled cutting bit of one or more grooves from 3 in. to 4 in. long. As the drill bit is held against the web of the rail, water or oil is applied to the point to keep it cool, as the drilling progresses. Drill bits are made of high speed steel or of low carbon steel to which are welded high speed steel tips, usually of tungsten steel.

DUMP CAR. A car designed to discharge its load through doors in the sides or floor or by tipping the body, usually by means of outside mechanical attachments.

Those in general use in maintenance of way service include convertible cars, hopper bottom equipment and side dump cars. End dump and rotary dump cars, sometimes used in construction work, are usually limited to the narrow gage, four-wheeled styles of less than 5 cu. yd. capacity, while construction side dump cars are generally of 4 to 20 yd. capacity, those selected for railway grading being commonly equipped with compressed air and standard M. C. B. attachments and of 12 cu. yd. minimum capacity. The general development of the dump car is along two distinct lines: equipment designed for general use and that which is reserved for special service.

The convertible car has movable sides, ends and floor so arranged that the body may be transformed from the gondola to the center dump, or side dump type. Convertible cars are commonly made with steel underframes, with four wheel trucks, air brakes and safety appliances and in capacities of 70,000 lb. and up. The convertible features of this style of car, which consist of a shifting of parts, adapt it to ready interchange from the special maintenance type to one that is suitable for revenue service.

Side dump cars are made in a number of designs and in many sizes in wood or steel from the ½ ton narrow gage equipment to standard gage cars of 50 tons capacity or over. In order to dump the contents at either side the car body is center hung, usually pivoted at the ends and high enough above the running gears to tilt steeply to discharge the contents. The largest types have their bodies supported on rockers so arranged over the bolsters as to be slightly out of side balance when loaded so



Thirty Yard Convertible Dump Car in Side Dump and Center Dump Positions
The Rodger Ballast Car Co.
(See Page 798)

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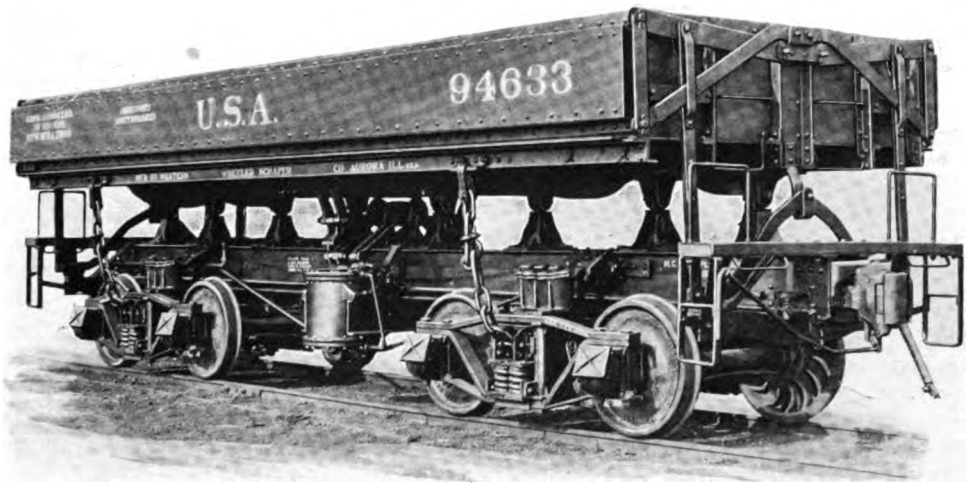
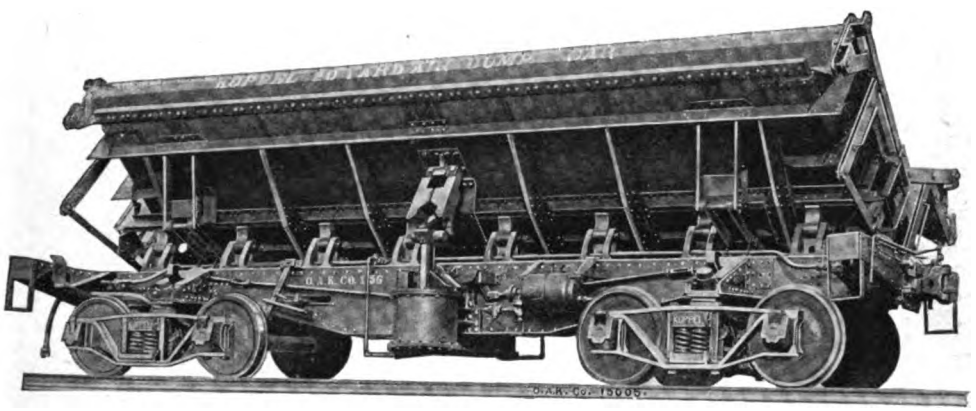
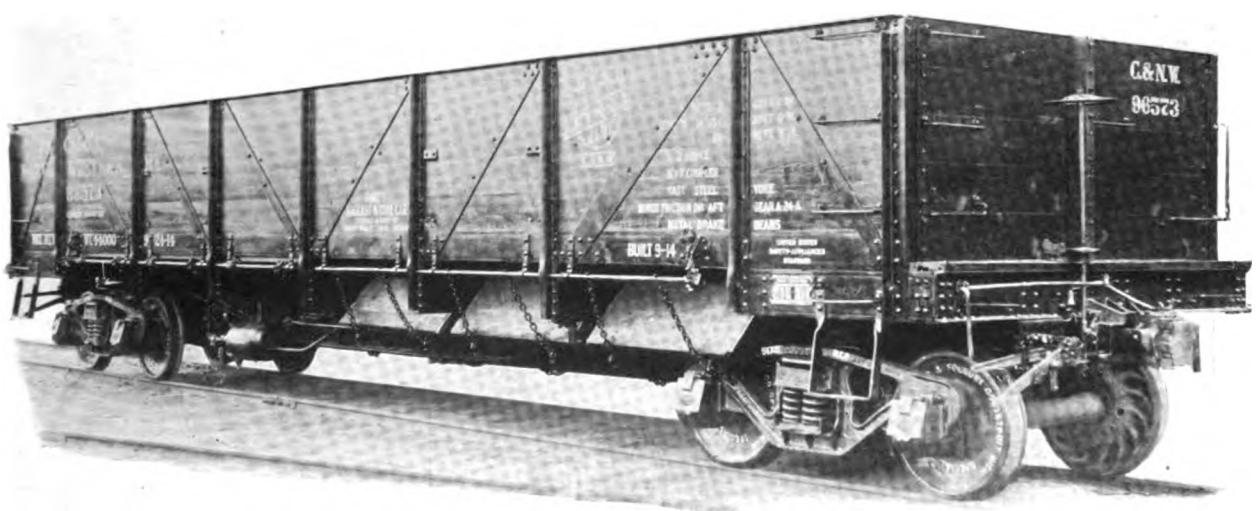


Twenty Yard Air Dump Car in Loaded Position
The Western Wheeled Scraper Co.
(See Page 834)



Twenty Yard Air Dump Car
The Koppel Industrial Car & Equipment Co.



Thirty Yard Drop Bottom Side Dump Car
The Rodger Ballast Car Co.
(See Page 798)

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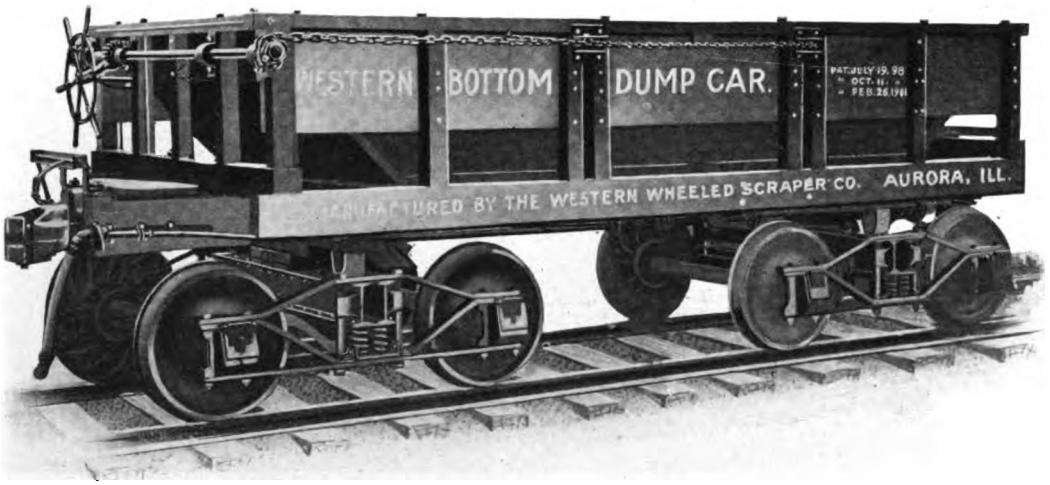
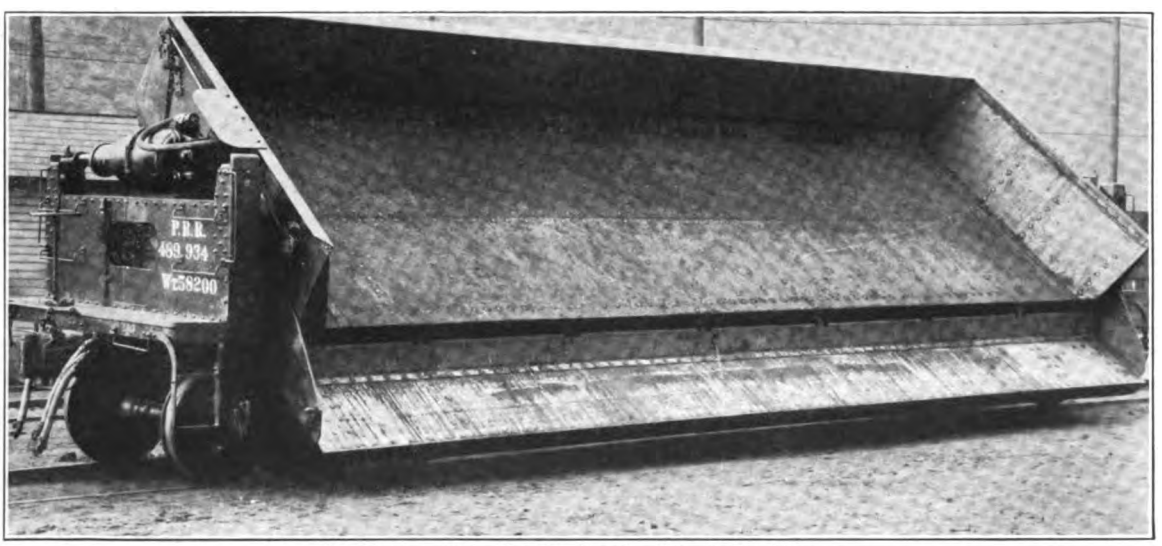


Twelve Yard Bottom Dump Car
The Western Wheeled Scraper Co.
(See Page 834)

Extension Side Dump Car in Loaded Position
Clark Car Company
(See Page 670)



Extension Side Dump Car in Tilted Position
Clark Car Company
(See Page 671)

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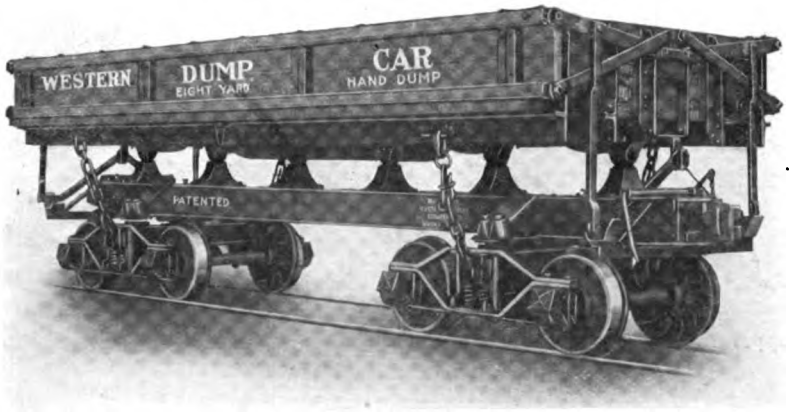
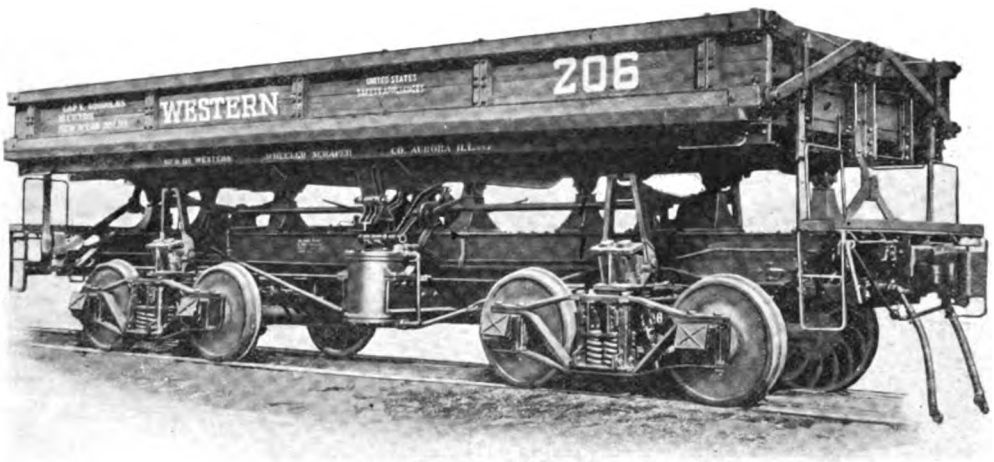
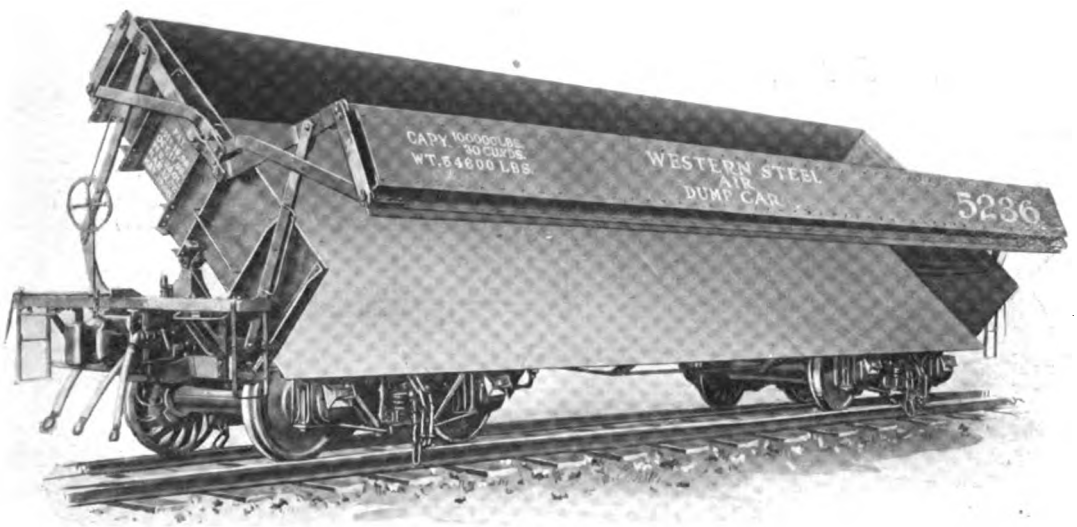


Eight Yard Hand Side Dump Car
The Western Wheeled Scraper Co.
(See Page 834)



Sixteen Yard Air Equipped Side Dump Car
The Western Wheeled Scraper Co.
(See Page 834)



Thirty Yard Air Dump Car
The Western Wheeled Scraper Co.
(See Page 834)

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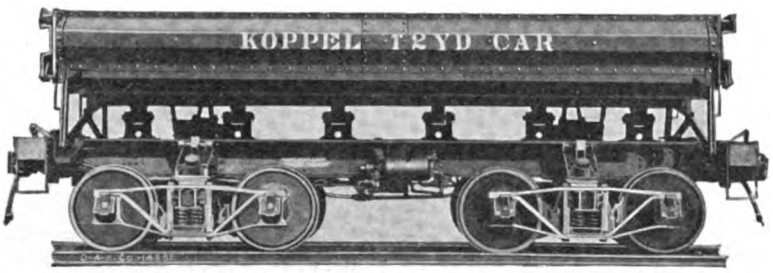
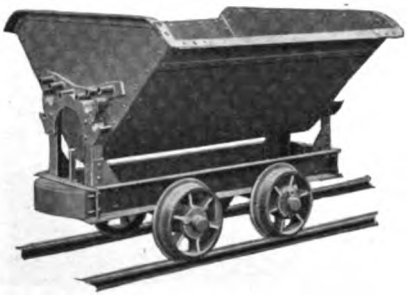
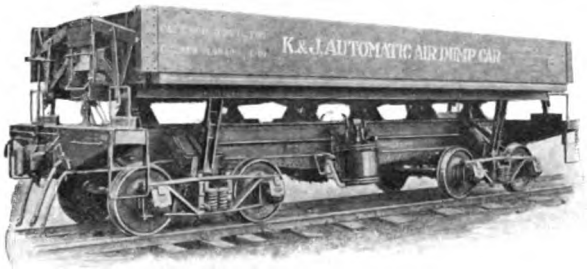


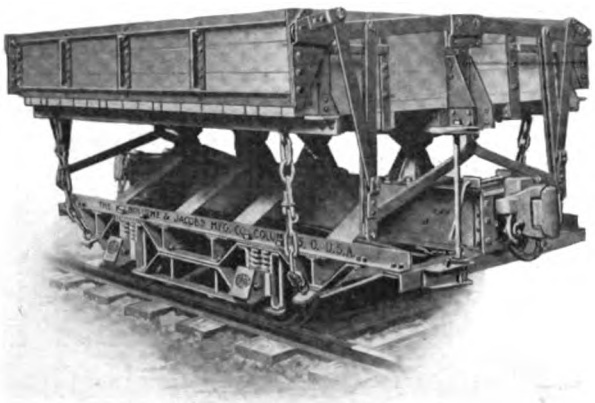
Twelve Yard Dump Car
The Koppel Industrial Car and Equipment Co.



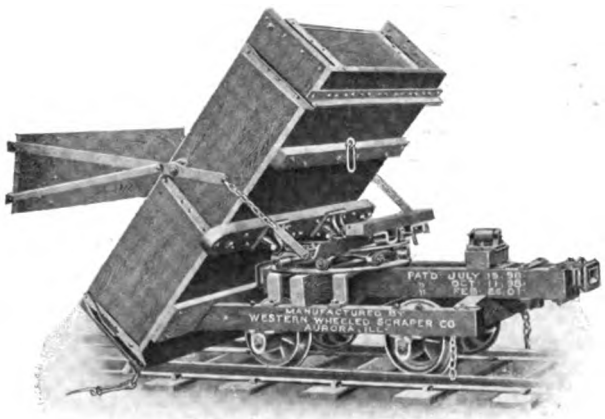
Trough-Shaped Side Dump Car
The Light Railway Equipment Co.



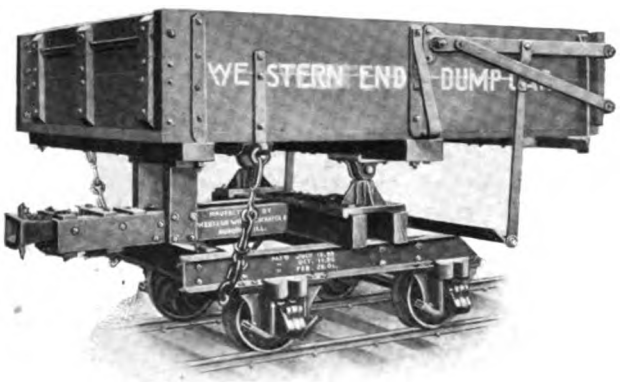
All Steel Automatic Dump Car
The Kilbourne & Jacobs Manufacturing Co.
(See Page 732)



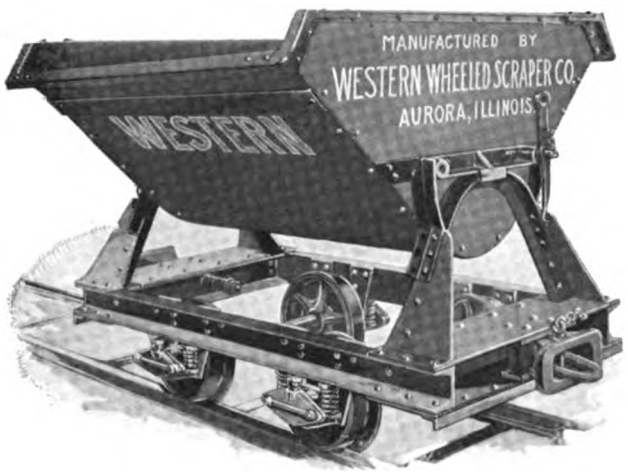
Sway Side Dump Car
The Kilbourne & Jacobs Manufacturing Co.
(See Page 732)



Rotary Dump Car
The Western Wheeled Scraper Co.
(See Page 834)



End Dump Car
The Western Wheeled Scraper Co.
(See Page 834)



Trough-Shaped Side Dump Car
The Western Wheeled Scraper Co.
(See Page 835)

Automatic Side Dump Car
The Kilbourne & Jacobs Manufacturing Co.
(See Page 732)

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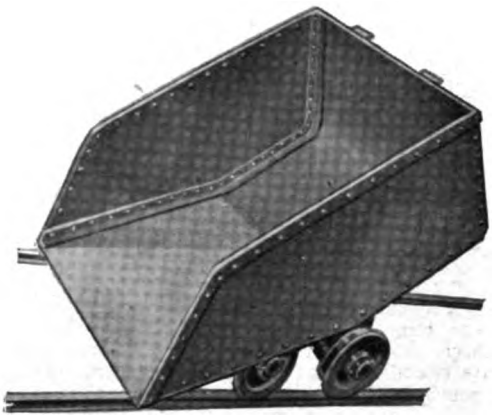
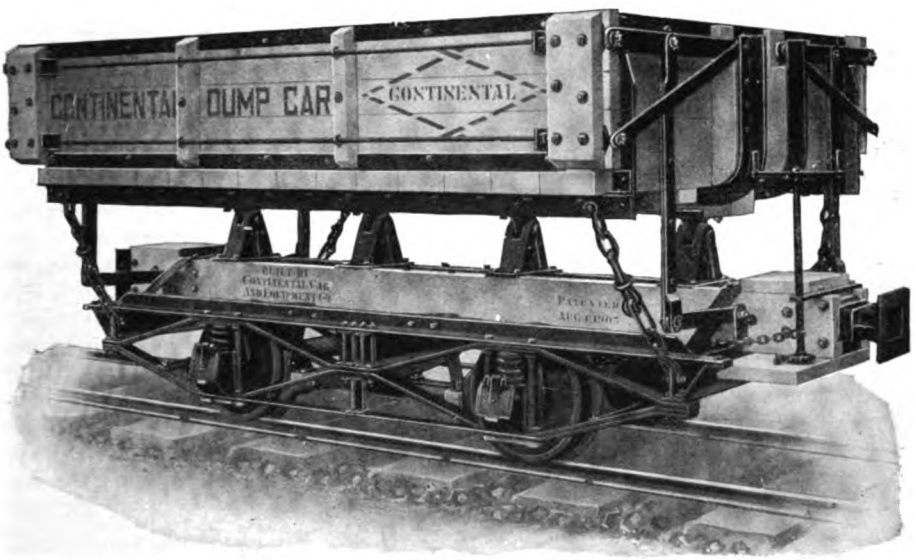
that an application of the compressed air unloading device, with which most dump cars of 20 tons capacity and over are equipped, dumps the load while the bottom hinged side falls as an apron to extend the side movement of the load well clear of the rails; and with the shutting off of the air, the car body being released from its over-balanced condition, rights and locks itself in the horizontal position. Another type of side dump car has an end device which raises the movable side clear of the discharging load when the floor is tilted. A type of four-wheeled side dump car in common use and of capacity usually less than 12 cu. yds., has two-piece, adjustable hand-dump side, chains fastened to the truck frames below and to the corners of the car floor above. Some of these dump cars have ends fitted with a system of outside levers which automatically lift the closed side of the car from the floor as the body is tilted to dump the load, lowering it again as the body returns to the horizontal position. Some of the types of smaller construction cars have sides which are integral with the floors and ends, while some have rounded bottoms which extend upward to form the diverging sides. See Ballast Car.

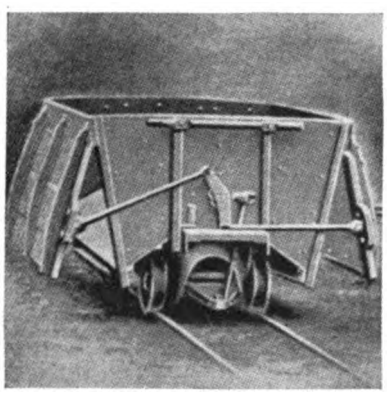
End Dump Car
The Western Wheeled Scraper Co.
(See Page 834)



Swivel Body Scoop Car
The C. W. Hunt Company, Inc.
(See Page 710)



Six Yard Sway Side Dump Car
The Continental Car Co.



Side Door Self-Dumping Car
The C. W. Hunt Company, Inc.
(See Page 710)

E

EASER. See Heel Riser Block (Frog). Also Frog.

EASEMENT CURVE. A curve of gradually increasing radius introduced between straight track and circular curves to overcome the effects on rolling stock of sudden changes of direction, and to

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permit the gradual tilting of the track until the outer rail attains the required super-elevation to overcome the effect of centrifugal force.

The A. R. E. A. standard practice in the use of easement curves is as follows:

Easement curves should be used with all curves requiring an elevation of 2 in. or more for the highest permissible speed.

The choice of easement curves should be governed by the ultimate speed possibilities, considering probable revision of the worst features of alinement, rather than by existing schedule speed.

With curves of 6 degrees and over, which are speed-limiting curves, easement curves should be not less than 240 ft. long.

With speed-limiting curves of less than 6 deg., easement curves should have lengths in feet of not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 in.

With curves which are not likely to limit speed, easement curves should have lengths in feet of not less than 30 times the elevation in inches for the ultimate speed, nor less than ⅔ the ultimate speed in miles per hour times the elevation in inches.

Longer easement curves than the minimum lengths thus determined may be used to advantage and will be convenient sometimes, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration of the effect on cost. For minor curves an increase in length of about 50 per cent over the minimum is recommended when such increase will not seriously affect the cost nor adversely affect the degree of curve. The minimum lengths should be used in all cases where greater lengths would adversely affect the degrees of main curves.

Curve elevations should be attained and run out uniformly over the full length of easement curves with no elevation on tangents and full elevation on circular curves.

Easement curves should be used between curves of different degrees, and change of elevation should be effected just as between curves and tangents.

Any form of easement curve is satisfactory:

(1) In which the rate of increase in degree of curve can readily be changed to suit particular cases so that the length of easement curve shall be the same as the distance in which the outer rail is raised from nothing to full elevation.

(2) Which can be run in by deflection or offset with chords of any desired length.

(3) Which is of the general type of either the Searles spiral, the cubic parabola, or the Holbrook, Crandall, Talbot, and 10-chord spiral.

The 10-chord spiral is recommended. Chords of any part of the spiral length may be used in staking out the 10-chord spiral when the central angle is small. To secure the most accurate results chords approximately one-tenth the length of spiral should be used when the central angle exceeds 15 deg.

The following table represents the common practice in the elevation of the outer rail on circular curves for various train speeds (A. R. E. A.):

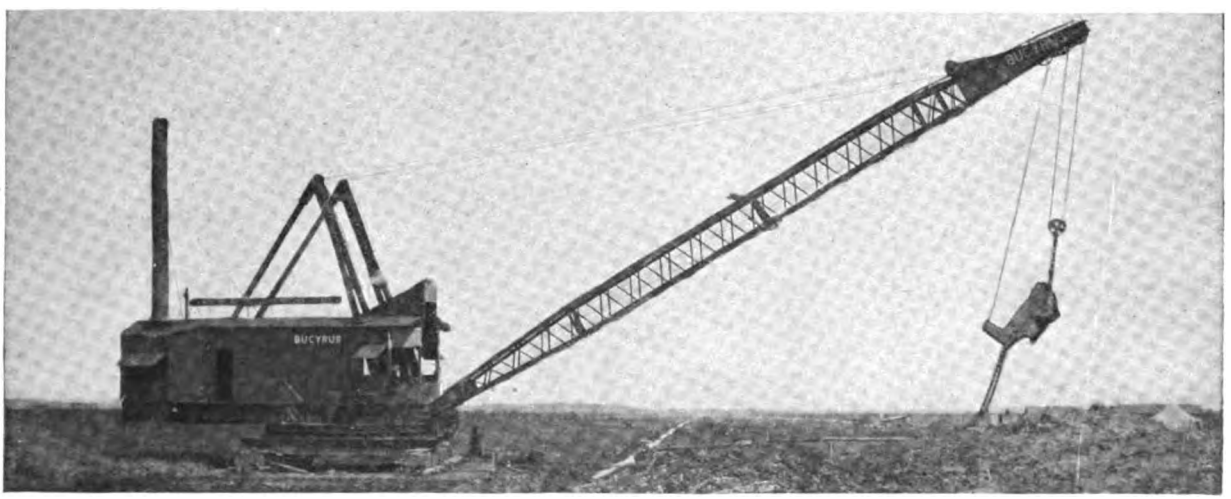
ELEVATION OF OUTER RAIL IN INCHES.

Degree of Curve	Velocity in Miles per Hour.													Degree of Curve
	10	15	20	25	30	35	40	45	50	55	60	65	70	
1	0	⅛	¼	⅜	½	¾	1⅛	1⅜	1⅝	2	2⅜	2¾	3¼	1
2	⅛	⅜	½	⅞	1⅛	1⅜	2⅛	2⅝	3¼	4	4¾	5½	6½	2
3	¼	½	¾	1¼	1¾	2⅜	3⅛	4	4⅞	6	7⅛	8⅜	9¾	3
4	¼	⅝	1	1⅝	2⅜	3¼	4¼	5⅜	6⅝	8	9½	...	...	4
5	⅜	¾	1¼	2	3	4	5¼	6⅝	8¼	...	...	...	...	5
6	⅜	1	1⅝	2½	3½	4⅞	6¼	8	...	...	...	...	...	6
7	½	1⅛	1⅞	2⅞	4⅛	5⅝	7⅜	...	...	...	...	...	...	7
8	½	1¼	2⅛	3¼	4¾	6½	8⅜	...	...	...	...	...	...	8
9	⅝	1⅜	2⅜	3¾	5⅜	7¼	...	...	...	...	...	...	...	9
10	¾	1½	2⅝	4⅛	5⅞	8⅛	...	...	...	...	...	...	...	10
11	¾	1¾	2⅞	4½	6½	8⅞	...	...	...	...	...	...	...	11
12	⅞	1⅞	3⅛	4⅞	7⅛	...	...	...	...	...	...	...	...	12
13	⅞	2	3⅜	5⅛	7¾	...	...	...	...	...	...	...	...	13
14	1	2⅛	3⅝	5¾	8⅜	...	...	...	...	...	...	...	...	14
15	1	2¼	3⅞	6¼	8⅞	...	...	...	...	...	...	...	...	15
16	1⅛	2½	4¼	6⅝	...	...	...	...	...	...	...	...	...	16
17	1¼	2⅝	4½	7	...	...	...	...	...	...	...	...	...	17
18	1¼	2¾	4¾	7½	...	...	...	...	...	...	...	...	...	18
19	1⅜	2⅞	5	7¾	...	...	...	...	...	...	...	...	...	19
20	1⅜	3	5¼	8⅛	...	...	...	...	...	...	...	...	...	20

Ordinarily an elevation of 8 in. should not be exceeded. Speed of trains should be regulated to conform to the maximum elevation used. The inner rail should be maintained at grade.

EXCAVATION, COMMON. Earth, loose gravel, detached rock measuring one cu. ft. and under and all other material which can be readily removed without machinery or explosives.

EXCAVATOR, DRAG LINE. A revolving, long-boomed, power-operated crane designed to handle a box scraper at the end of a wire cable. This machine is frequently used in excavations not suitable for steam shovels nor accessible to horse-drawn scrapers. The drag line bucket is a rectangular steel



Drag Line Excavator
The Bucyrus Co.

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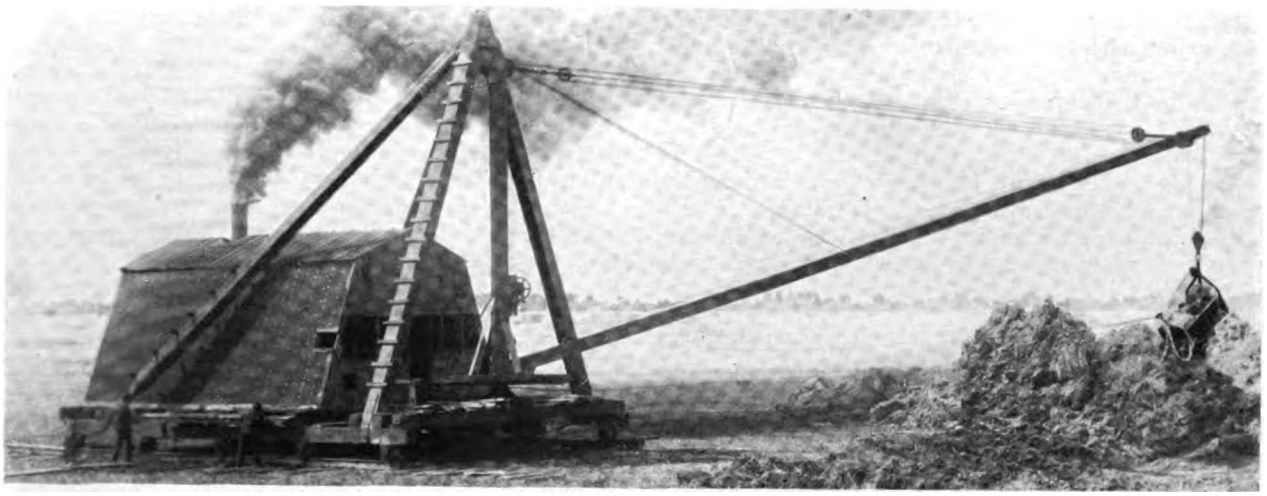

Drag Line Excavator
The American Hoist & Derrick Co.

box having one end open to admit the earth or other material, which is loosened as the bucket is dragged over it by means of several sharp, beveled steel teeth fastened to the mouth of the pan. A chain bale is hooked to its sides at the front and another at the rear to which the hoisting and drag lines may be fastened to operate in handling the load.

F

FACE (Tie). The upper or lower plane surface of a tie. A. R. E. A.

FACING POINT SWITCH. A switch, the points of which face the main traffic. The wheels of vehicles on main track pass over the points of a facing point switch before they reach the frog. Facing point switches are especially objectionable on double track lines where all the traffic is "against" them, on account of the danger of derailments caused by wheels fouling the point of the frog. For this reason no facing point switches in high speed main tracks are allowed on some railways. To avoid them crossovers between main tracks are usually installed to trail the switches.

FALSE POINT. The point formed by the intersection of guard rails in a double pointed frog.

FENCE. A barrier usually erected along the sides of an open space or around an enclosure to restrain entrance, as to a railway right-of-way and adjoining fields. Common types of fence consist of a line of posts supporting connecting wires, or rails with pickets. The term is also applied to any wall, hedge or other such structure built to restrict ingress and egress.

Although railway buildings, yards, etc., are enclosed by fences, by far the greatest mileage of fencing material is used by railroad companies for separating their rights-of-way from adjoining properties. These right-of-way fences are commonly erected along the railway boundary lines on each side of the tracks, except at highway grade crossings, station grounds and other property to which the public has the rights of access; the primary purpose of fencing being to promote safety by preventing trespass on the tracks. To complete the enclosure at the ends of right-of-way fences, as at a highway crossing at grade, connecting wing fences are built across the right-of-way from each side, ending in inclined cross panels or aprons between which a stock guard is located to prevent animals from entering between the rails. Gates are provided at private grade crossings, while at under and over crossings and bridges the wing fences end at the structures in such a manner as to leave no open or unguarded space. Auxiliary fences are frequently placed beneath bridges between the abutments to prevent stock from crossing under the tracks. Barriers are also commonly maintained in

High Mesh Wire Fence with Non-Climbable Steel Posts
The Chicago Steel Post Co.

and around railway yards to keep persons and animals away from the trains, railway facilities and supplies; also at stations to guide passengers to trains and to enclose other railway property.

Railway fencing practice has developed slowly along the lines of permanency from the use of wooden fence boards to the galvanized barbed wire and smooth types and still later to woven wire, which is now frequently used with iron or reinforced concrete posts, as well as with creosoted and un-

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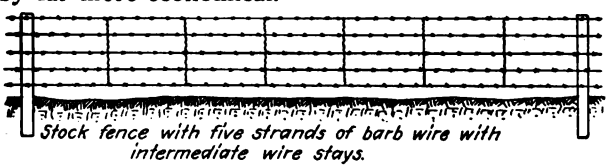
treated wooden posts. This development has been due principally to the short service life of wooden fencing owing to decay and fire losses, to the decrease in the timber supply and to the tendency toward conservation of labor in the building and maintenance of fence.

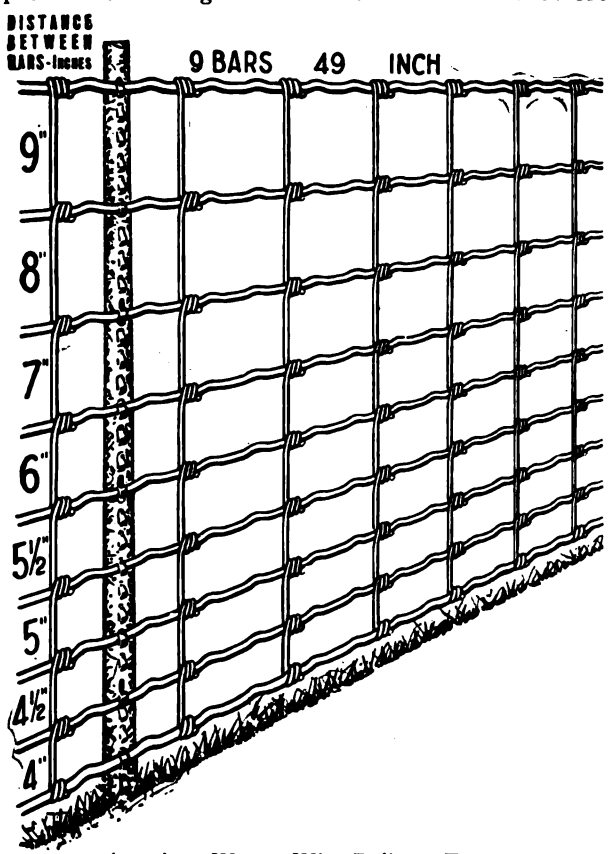
Wooden fence boards being usually 16 ft. long the posts must be set for 8 ft. panels to obtain a reasonably firm fence structure, whereas the wire fence posts are frequently set as far as 30 ft. apart especially when intermediate stiffeners are used. The labor of digging post holes alone renders the wooden fence much more expensive in first cost than the wire fence. Considering the comparatively short service life of the wooden fence the wire structure is by far more economical.



Stock fence with five strands of barb wire with intermediate wire stays.

A Common Type of Barbed Wire Fence

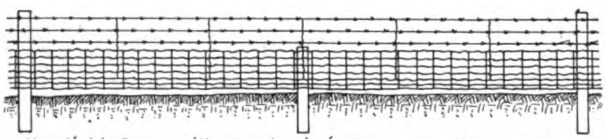
The life of fence wire, staples, iron posts, etc., formerly limited to a few years on account of corrosion, is now commonly extended by coating the material with zinc, applied by the process of galvanizing. The single fence wires are given their protective coating in a bath of melted zinc before



American Woven Wire Railway Fence
The American Steel & Wire Co.
(See Page 644)

fabrication. This coating must be of uniform thickness and substantial enough to withstand the twisting to which the wire is subjected in the manufacture, erection and maintenance of the fencing without exposing any portion of the iron to the action of the elements. Wire fencing of mesh similar to the woven type, made by electrically welding the crossed wires at their intersections, as well as iron posts and staples are preferably galvanized after manufacture.

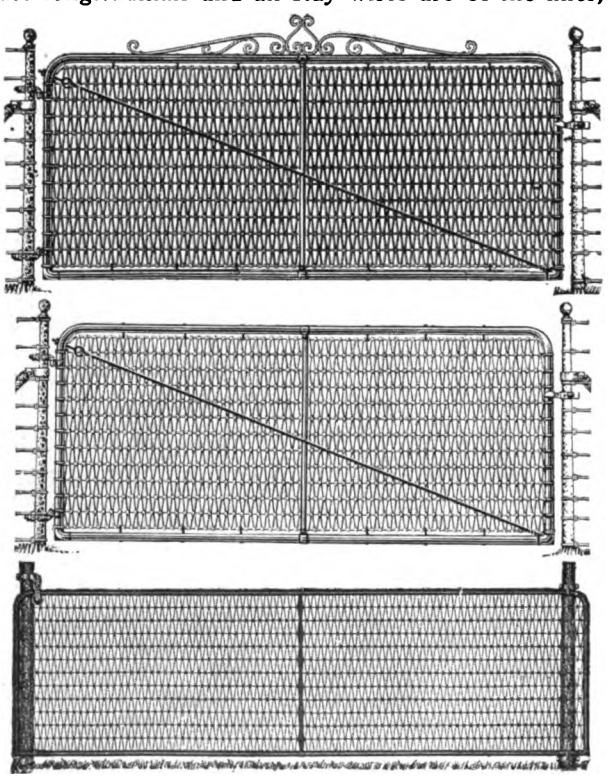
Barbed wire fencing is cheaper to install and maintain and longer lived than a board fence, and admits of spacing posts as desired, even to placing them 30 ft. or more apart by fastening the wires to intermediate vertical wooden stay slats. Woven wire fencing is still more permanent and effective because it is made of smooth wires meshed together strongly in a way affording little opportunity for stock to get caught and injured between the strands.



Hog tight fence with twenty six inch woven wire, and three strands of barb wire above, supported by intermediate wire stays.

A Common Type of Hog Tight Fence

Three classes of galvanized fence are recognized as standard by the A. R. E. A. Class A fence is made of nine longitudinal wires interwoven with a transverse stay wire every 12 in., the top and bottom longitudinals being No. 7 gage while the intermediate longitudinals and all stay wires are of the finer,



Wire Gates
The American Steel & Wire Co.
(See Page 645)

No. 9 gage. The successive longitudinal wires of the weave, starting from the bottom, are placed 4, 4½, 5, 5½, 6, 7, 8 and 9 in. apart. Class B fence has seven No. 9 gage longitudinal wires spaced 6½, 7,

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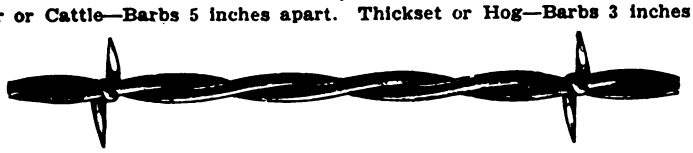
7½, 8, 8½ and 9 in. apart, starting at the bottom, and woven with No. 9 stay wires every 18 in., while the Class C type consists of No. 9 wires, five longitudinals spaced 7½, 8, 8½ and 9 in. apart with stay wires 24 in. apart. A fourth A. R. E. A. type is a 5-strand fence of smooth, round, flat ribbon or barbed wire spaced 10, 10, 12 and 12 in. apart without stay wires.

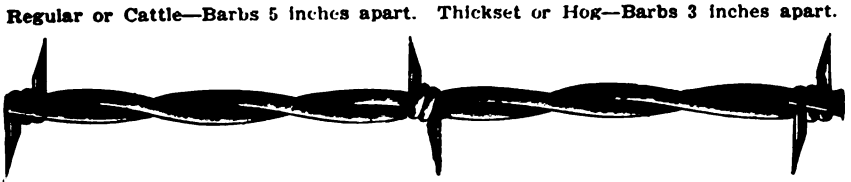
BAKER PERFECT. TWO POINT.
Flat barbs, short and sharp.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.

ELLWOOD JUNIOR, TWO POINT.
Half-round Barbs, short and sharp.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.

WAUKEGAN TWO POINT.
Half-round Barbs, short and sharp.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.

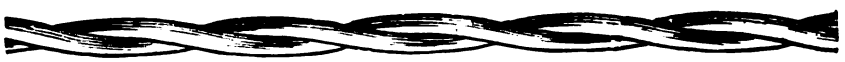


AMERICAN GLIDDEN. TWO POINT.
Round Barbs
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.



LYMAN, FOUR POINT.
Round Barbs.
Regular or Cattle—Barbs 5 inches apart. Thickset or Hog—Barbs 3 inches apart.

BARBLESS FENCING.
Two-Ply Twisted Galvanized Barbless Fencing. Sizes 11 to 14 inclusive.
3-Ply, 4-Ply, 5-Ply and 6-Ply Twisted Barbless Fencing. Sizes 7 to 14 inclusive.



Tension curves are provided in the longitudinal strands of all woven wire fencing to take up contraction and expansion. These tension curves are formed by crimping the wires during manufacture.

Right-of-way fences are frequently built for certain kinds of stock, the barbed wire type of the western states being designed particularly as a cattle fence, while the woven wire fencing which is largely used in the eastern states makes a more effective barrier against smaller animals.

The A. R. E. A. separates right-of-way fences into four different classes along these general lines as follows:

Specifications for Standard Right-of-Way Fences

1. **Classes.** Standard right-of-way fences shall be divided into four classes, the height to conform to statutory requirements, generally about 4 ft. 6 in. above the ground.

2. **Class A Fence.** A Class A fence shall consist of nine longitudinal smooth galvanized steel wires; the top and bottom wires shall be No. 7 gage; the intermediate and stay wires shall be No. 9 gage. The spacing of the longitudinal wires, commencing at the bottom, shall be 4, 4½, 5, 5½, 6, 7, 8 and 9 in. The bottom wires shall be 5 in. above the ground and the stay wires shall be spaced 12 in. apart. When used as a hog-tight fence, the bottom wire shall be not over 3 in. above the ground, with a strand of barbed wire 1½ in. below same.

3. **Class B Fence.** A Class B fence shall consist of seven longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage. The spacing of the longitudinal wires, commencing at the bottom, shall be 6½, 7, 7½, 8, 8½ and 9 in. The bottom wire shall be 7 in. above the ground and stay wires shall be spaced 18 in. apart.

4. **Class C Fence.** A Class C fence shall consist of five longitudinal smooth galvanized steel wires; the longitudinal and stay wires shall be No. 9 gage. The spacing of the longitudinal wires, commencing at the bottom, shall be 7½, 8, 8½ and 9 in. The bottom wire shall be 9 in. above the ground and the stay wires shall be spaced 24 in. apart.

5. **Class D Fence.** A Class D fence shall consist of five strands of galvanized steel ribbon, smooth, round or barbed wire fencing. The spacing of the wires, commencing at the bottom, shall be 10, 10, 12 and 12 in. The bottom wire shall be 10 in. above the ground. The longitudinal wires of all woven wire fencing under Classes A, B and C shall be provided with tension curves to take any expansion and contraction.

Material

6. **Wood Posts.** Posts shall be made of cedar, locust, chestnut, Bois d'Arc, white oak, mulberry, catalpa or other durable wood native to the locality, or of treated timber. They shall be straight and free from splits, rot or other defects. If sawed or split posts are used, their dimensions shall be at least equal to those hereinafter specified for round posts.

7. **End Posts, Etc.** End, corner, anchor and gate posts shall be at least 8 ft. long and 8 in. in diameter at the small end, set 3 ft. 4 in. in the ground.

8. **Intermediate Posts.** Intermediate or line posts shall be at least 7 ft. long and 4 in. in diameter at the small end, set 2 ft. 4 in. in the ground.

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9. **Braces.** Braces for end, corner, anchor and gate posts shall be made of intermediate or line posts or 4 in. by 4 in. sawed lumber of a quality equal in durability to that of the posts, and free from large knots, splits, rot and other defects.

10. **Concrete Posts.** Concrete posts shall consist of one part Portland cement to four parts run of pit gravel; or one part Portland cement, two parts clean, sharp sand and four parts crushed stone of low absorption or screened gravel. Broken stone or gravel shall be of such size as will pass through a ½ in. screen but be retained on a ¼ in. screen.

11. **End Posts, Etc.** End, corner, anchor and gate posts shall be at least 8 ft. long, 6 in. square at the top and 8 in. square at the base, set 3 ft. 4 in. in the ground. The reinforcement shall consist of four ⅜-in. sq. twisted rods.

12. **Intermediate Posts.** Intermediate or line posts shall be at least 7 ft. long, 4 in. at the top and 5½ in. at the base, set 2 ft. 4 in. in the ground. The reinforcement shall consist of 3 in. sq. or 4¼ in. sq. twisted rods, depending on the design of the posts.

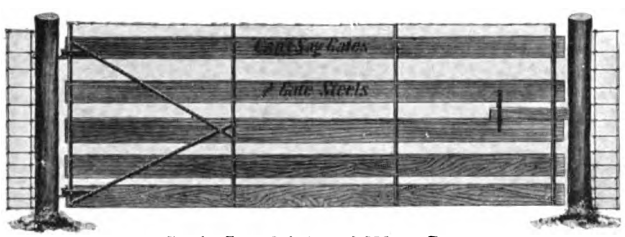
13. **Braces.** Braces for end, corner, anchor and gate posts shall be made of concrete, 4 in. by 4 in. in section, reinforced with 4¼ in. sq. twisted rods.

14. **Wire.** Woven wire fences shall be constructed of basic open-hearth galvanized steel wire. It must stand, without sign of fracture, winding tight around wire of the same size.

15. **Locks.** The locks or fastenings at the intersection of the longitudinal and stay wires shall be of such design as will prevent them from slipping either longitudinally or vertically.

16. **Staples.** The staples used for fastening the longitudinal wires to the posts shall be made of No. 9 galvanized steel wire. They shall be 1 in. long for hard wood and 1½ in. long for soft wood.

17. **Galvanizing.** The galvanizing shall consist of an even coating of zinc, which shall withstand one-minute immersion tests in a solution of commercial sulphate of copper crystals and water, the specific gravity of



Can't-Sag Right-of-Way Gate
The Rowe Manufacturing Co.

which shall be 1.185 and the temperature of which shall be from 60 deg. to 70 deg. F. Immediately after each immersion the sample shall be washed in water and wiped dry. If the zinc is removed, or a copper-colored deposit formed at the end of the fourth immersion, the lot of material from which the sample is taken shall be rejected.

18. **Manufacture.** The fence shall be so fabricated as not to remove the galvanizing or impair the tensile strength of the wire.

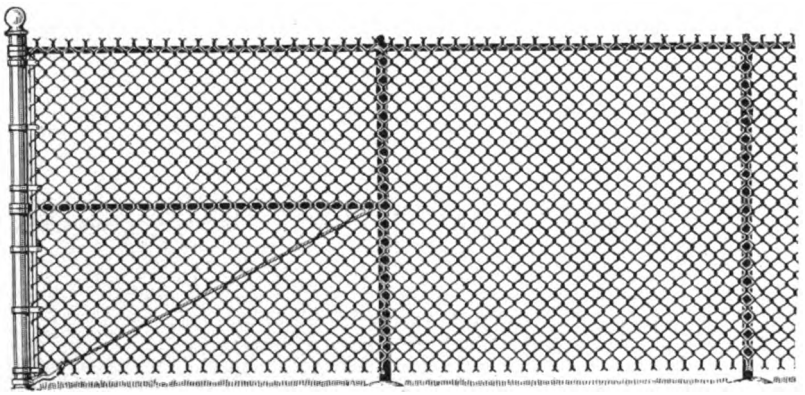
Erection

19. **End, Corner, Anchor and Gate Posts.** End, corner, anchor and gate posts shall be set vertically, at least 3 ft. 4 in. in the ground, thoroughly tamped, braced and anchored.

20. **Intermediate or Line Posts.** Intermediate or line posts shall be set at least 2 ft. 4 in. in the ground and 16½ ft. apart.

21. **Post Holes.** Holes of full depth shall be provided for all end, corner, anchor and gate posts, even if blasting must be resorted to. For intermediate or line posts, where rock is encountered, not more than two adjacent wood posts shall be set on sills 6 in. by 6 in. by 4 ft. long, braced on both sides by 2 in. by 6 in. braces, 3 ft. long. Holes shall be provided for all other posts. Posts shall be set with the large ends down and in perfect line on the side on which the wire is to be strung. After the fence is erected, the tops of the wood posts shall be sawed off with a ¼ pitch, the high side being next the wire and 2 in. above it.

22. **Anchoring.** Wood end, corner, anchor and gate posts shall be anchored by gaining and spiking two cleats to the sides of the post, at right angles to the line of the fence, one at the bottom, the other just



Cyclone National Railway Fence Showing End Post with Brace
The Cyclone Fence Co.

below the surface of the ground. The cleat near the surface of the ground shall be put on the side next the fence, and the bottom cleat shall be put on the opposite side. Intermediate wood posts set in depressions in the ground shall be anchored by gaining two cleats into the side of the post, near the bottom and properly spiking them.

23. **Cleats, Sills, etc.** All cleats shall be 2 in. by 6 in. by 2 ft. long. All sills, braces and cleats shall be made of sawed lumber of a quality equal in durability to that of the posts.

24. **Bracing.** Wooden end, corner, anchor and gate posts shall be braced by using an intermediate or line post, or a piece of 4 in. by 4 in. sawed lumber of a quality equal in durability to that of the posts, gained into the end, corner, anchor or gate post, about 12 in. from the top and into the next intermediate or line post about 12 in. from the ground and securely spiked. A cable made of a double strand of No. 9 galvanized soft wire looped around the end, corner, anchor or gate post near the ground line, and around the next intermediate or line post about 12 in. from the top shall be put on and twisted until the top of the next intermediate or line post is drawn back about 2 in. Four-inch by 4 in. reinforced concrete braces shall be used with concrete posts.

25. **Stretching.** Longitudinal wires shall be stretched uniformly tight and parallel; stays shall be straight, vertical and uniformly spaced. Wires shall be placed on the side of the post away from the track.

26. **Stapling.** Staples shall be set diagonally with the grain of the wood and driven home tight. The top wires shall be double stapled.

27. **Splicing.** Approved bolt clamp splice or a wire splice made as follows may be used: The ends of the wires shall be carried 3 in. past the splicing tools and wrapped around both wires backward from the tool for at least five turns, and after the tool is removed, the space occupied by it shall be closed by pulling the ends together. The use of smooth wire in preference to barbed wire is recommended for right-of-way fences. The use of heavy smooth wire, or a plank at the top of a barbed wire fence, is recommended. (See Page 639).

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FENCE BRACE. A piece of wood, metal or other material in compression, placed diagonally between adjacent posts. (A. R. E. A.)

Wooden braces are usually made of sawed timber. The stability of a wire fence depends directly on the strength and position of the brace, which should be in firm contact with adjacent posts and secure against slippage or displacement.

FENCE CLEAT. A piece of wood, metal or other material fastened crosswise to the base or side of a post below the surface of the ground to give it greater stability.

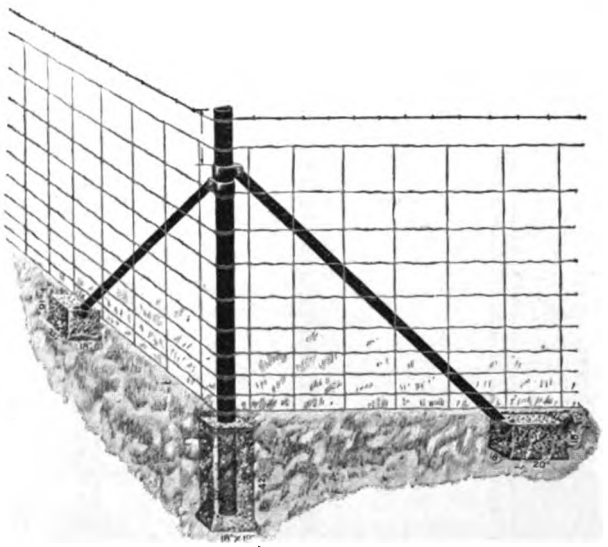
Cleats are useful to increase resistance to horizontal as well as vertical force. When fencing attached to a main post is stretched it develops a tendency to pull the top of the post toward the stretcher, the pressure at the top of the ground being exerted on the side toward the stretcher while the pressure at the bottom of the post is in the opposite direction. Therefore a top cleat is preferably fastened to the post on the pulling side and a bottom cleat on the opposite side. Corner posts are frequently cross-cleated to resist the pull of two fence lines.

FENCE PANEL. A section of fence between two adjacent posts. (A. R. E. A.)

A panel is sometimes utilized as a temporary gate, as in a wire fence where one end of the section is cut loose close to its supporting post and stapled to a movable wooden stay. Loose top and bottom loops of wire placed around the supporting post serves to hold the stay erect and keep the attached loose fencing reasonably taut when the gateway is not in use.

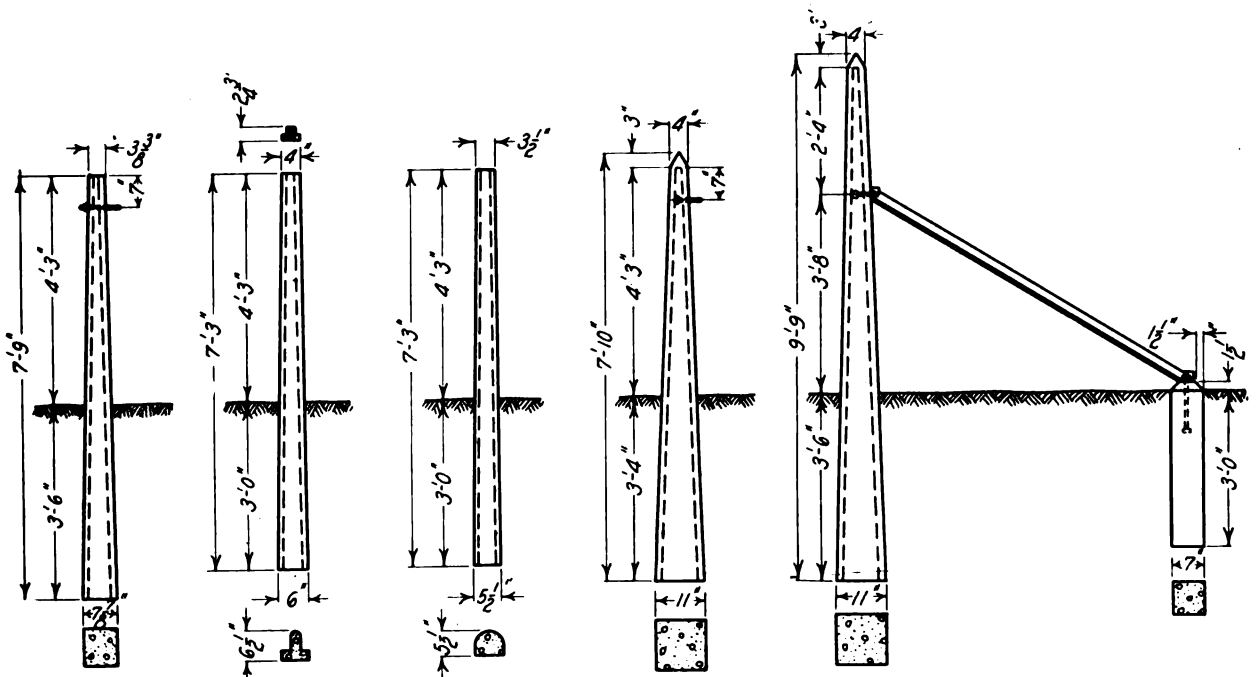
FENCE POST. A straight piece of wood, concrete, metal or other material, usually 7 to 8 ft. long, designed to be used as a vertical support for the longitudinal members of a fence.

The end, corner, gate and anchor posts are the main posts of a fence between which the fencing



Red Top Steel Corner Post and Braces
The Chicago Steel Post Co.

is stretched, the intermediate posts being set between them at regular intervals to support adjacent fence panels and to keep the fence in line but not to resist the pull of long spans of stretched fencing. The main posts are longer and stronger than intermediate posts, are set deeper in the ground or pre-



4 Pcs. 1" Sq. by 7'-8" Long Corrugated Wt. 6.75 Lb 0.60 Bags of Cement Volume 1.792 Cu. Ft.

3 Pcs. No. 5 Wire 7'-2" long Wt. 2.45 Lb 0.20 Bags of Cement Volume 0.595 Cu. Ft.

4 Pcs. No. 5 Rods 7'-2" long Wt. 3.26 0.32 Bags of Cement Volume 0.9063 Cu. Ft.

4 Pcs. ½" Sq. by 7'-6" long Twisted, Wt. 26.35 Lb 1.05 Bags Cement. Volume 3.185 Cu. Ft.

4 Pcs. ½" Sq. by 9'-6" Long Twisted-Wt. 32.3 Lb 1.14 Bags of Cement. Volume 4.025 Cu. Ft.

0.31 Bags of Cement Volume 1.045 Cu. Ft.

Five Typical Designs of Concrete Fence Posts

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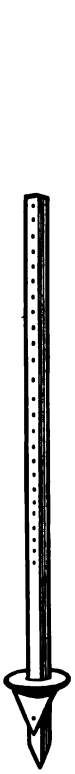
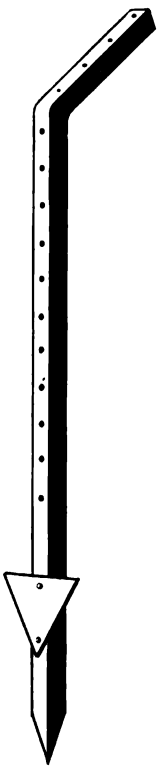
ferably in concrete, and are specially braced in the directions of the fence line or lines. A main post is frequently anchored against pulling out of the



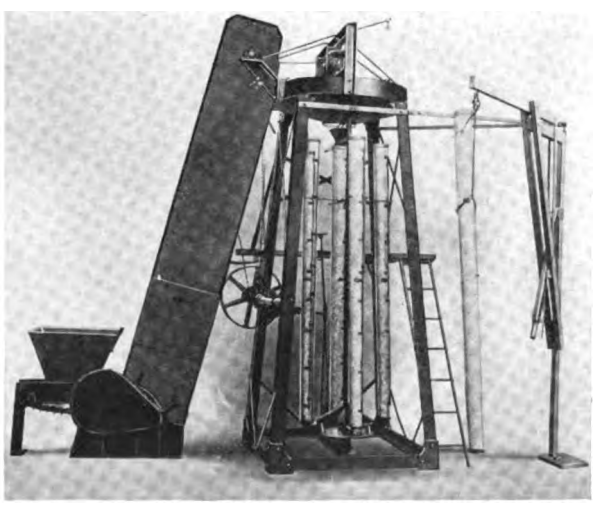
Red Top Steel Anchor Post
The Chicago Steel Post Co.



Red Top High Steel Fence Post
The American Steel & Wire Co.
(See Page 645)

Tubular Steel Line Fence Post

ground by fastening a wooden cleat or a steel flange crosswise at or near the bottom before planting it. Such devices are frequently used to anchor all the posts of wire fence extending across a piece of low ground to prevent the stretching of the wire be-



National Concrete Fence Post Machine
The National Concrete Machinery Co.
(See Page 754)

tween points on higher ground on either side from raising the fence out of the low ground.

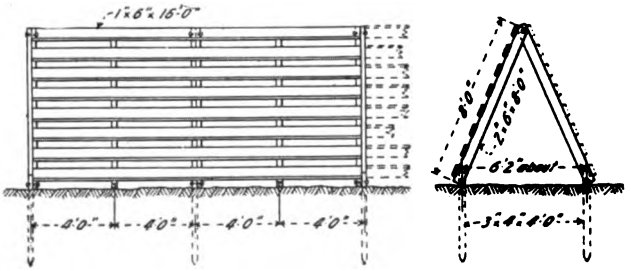
Although the panels of a fence may be of any standard length, posts being commonly placed from 8 ft. to 30 ft. apart according to the design of the fencing, the average distance between the wooden posts of woven wire right-of-way fence is 16 ft. 6 in. center to center, unless there are intermediate upright stays, when the distance between posts is sometimes as much as 45 ft. while the maximum distance between main posts is 330 ft. or 20 rods. It is considered good practice to set all posts deep enough in the ground to prevent them from being heaved up by frost. They are generally set butt end down, as their service life depends somewhat on the sectional area exposed to decay at the surface of the ground. Wooden posts are commonly cut from the tops of trees of long lived timber, or they are cut and split from the bodies of trees. Owing to the tendency to decay at or a little above the ground line, wooden posts are frequently treated with a timber preservative such as creosote, by standing them in open tanks filled to a depth of four feet with the preservative liquid, though the more thorough method of treating the entire post by the pressure method results in greater penetration and protection. Wooden posts are commonly placed in holes excavated for them. Pointing and driving wooden posts small end down is considered poor practice, as the points are easily pulled out or heaved up by frost, which causes the earth to alternately expand and contract.

Concrete posts are commonly tapered shapes reinforced with separate or trussed steel wire or rods. They are made in various sections, common types being square, round, half-round, ribbed and triangular. Some are provided with fastenings for fencing while other types depend on the friction of tie wires around the post to hold the fence. They are placed in prepared holes which should be of the least possible diameter.

Steel posts are made of various sections, such as flat bars, angles, T-section, H-section and tubular sections. They are commonly punched for holding wires and galvanized to increase their service life. Some metal posts have attachments for stretching fencing, which may be revolved at any time to take up slack in sagging wire. Some types of steel posts are designed to be driven, thereby eliminating the labor of digging and back filling the post holes, with the further advantage of settling more firmly in undisturbed ground.

FENCE, SNOW. Any barrier erected to prevent drifting snow from accumulating on railway tracks.

Snow which drifts with the wind is carried close to the surface of the ground and will swirl into and accumulate in railway cuts on account of eddies which are formed by the air currents passing over the excavated areas. Artificial eddies are created by snow fences in two positions, on the leeward side of an open fence and on the windward side of a tight



A. R. E. A. Standard Portable Snow Fence

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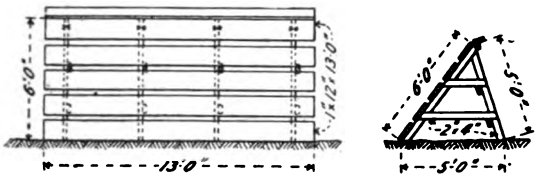
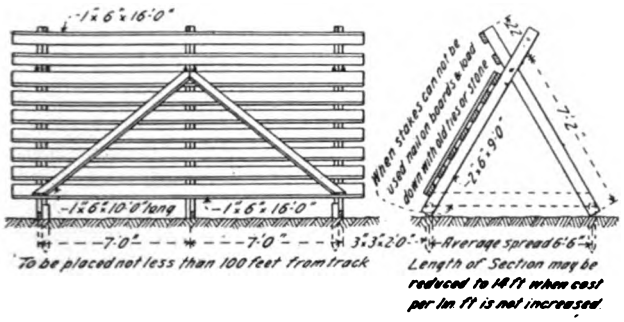
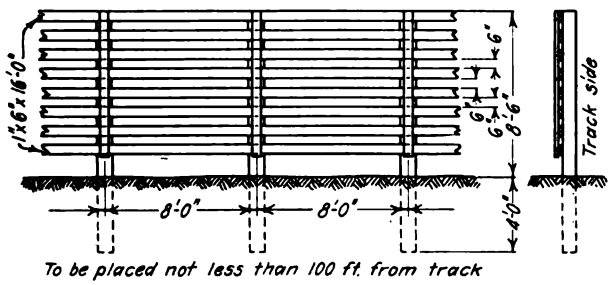


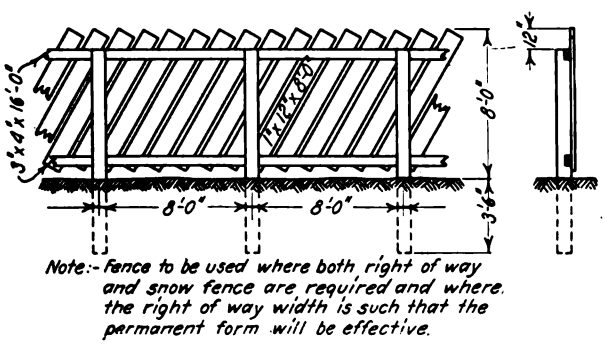
A. R. E. A. Standard Portable Snow Fence



A. R. E. A. Standard Portable Snow Fence



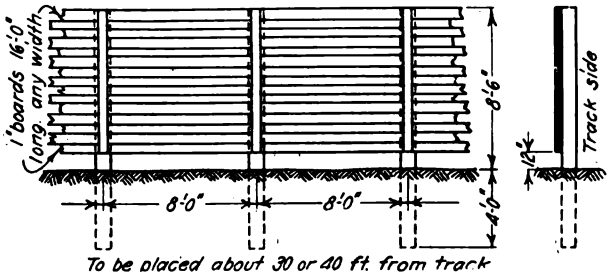
A. R. E. A. Standard Permanent Snow Fence



A. R. E. A. Standard Permanent Snow Fence

fence. Snow fence is made in permanent lengths or in portable sections, the portable fence being usually of open board construction half the height being open space with braces, designed to be staked in place.

Permanent snow fence is commonly tight board fence for severe climates or open board fence for climates where only moderate snow falls are usual, the tight board permanent fence being desirable especially where the right of way is 50 ft. or less in width. Where conditions permit, the permanent fence located on the right of way is most economical. Portable snow fence however is adaptable to changes in location to adjust the protection to the varying

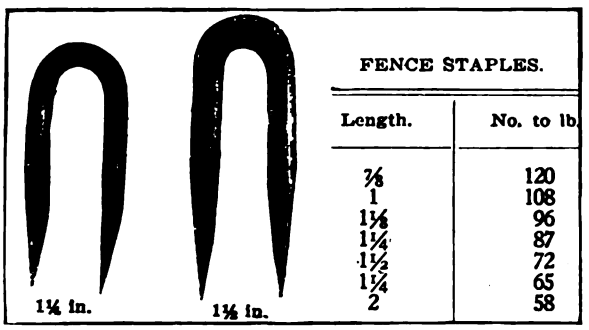


A. R. E. A. Standard Permanent Snow Fence

angles of the wind or to being placed at any distance from the tracks. It is frequently placed on the tops of snow banks in late winter.

Hedges, sod fences, stone fences and wind breaks of trees are also frequently used as protection against snow drifts.

FENCE STAPLE. A U-shaped metal device with sharpened ends used to fasten fence wires to wooden posts. It is commonly made of No. 9 or



FENCE STAPLES.

Length.	No. to lb.
⅞	120
1	108
1⅛	96
1¼	87
1½	72
1¾	65
2	58

A. R. E. A. Standard Wire Fence Staples

No. 10 galvanized wire from 1¼ in. to 1½ in. long with sharp points intended to be driven into wood diagonally across the grain.

FENCE STAY. A crimped or twisted wire, a wooden slat or a bar of metal used to stiffen a fence and to maintain the spacing of the longitudinal wires, each of which is fastened to it. Some fencing, reinforced with strong stays about 5 ft. long spaced at intervals of 8 ft., is erected on posts set as far as 45 ft. apart. (See Page 842).

FENCE, WING. A fence connecting the apron of a stock guard with the right-of-way or line fence. (A. R. E. A.)

To complete the enclosure of a section of railway right-of-way, four wing fences are erected, one between the line fence and the apron on each side of the stock guard at each end of the section. The posts of the end panels closest to the stock guard are cut off to allow the apron to lean back on them at an angle of about 45 deg. from the vertical to provide side clearance for rolling stock.

FILE, TRACKMAN'S. A flat steel rasp used to cut and abrade metal, especially to sharpen track tools.

The type of file in general track use is about 12 in. long, slightly tapering, but averaging 1 in. wide and ¼ in. thick. The butt is usually drawn to a long point for insertion in a straight wooden handle. The working faces of a file, which usually include

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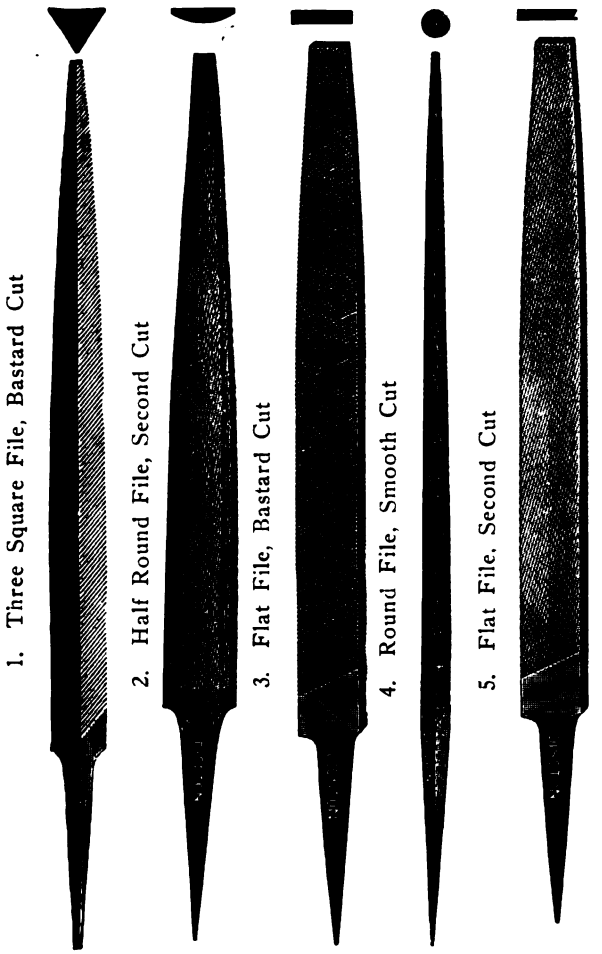


Trackmen's Files

all four surfaces, are supplied with parallel, equal, oblique ridges which abrade and cut into a softer metal when the file is rubbed across it. The faces of some files are cross furrowed to form pyramidal teeth instead of ridges. See Sharpener (General Section).

FILLER BLOCK. A metal separator made to exactly fill and maintain a space of desired dimensions between adjacent rails or parts of special track work such as frogs, guard rails, and crossings, usually in wheel flangeways.

Filler blocks are made of iron or steel of such composition as the service requires. They are usually held in place by bolts or rivets. See Frog. Also Guard Rail. Also Frog, Crossing.

FISH PLATE. A joint bar of rectangular section made to fit the web of the rail only. This section was in general use before the angle bar section was substituted with a view to obtaining added stiffness to the joint. Although the fish plate is commonly concave on the surface which fits the web of the rail so that the bearings are at the upper and lower web angles with a wedging action when the joint is tightened, there is no horizontal leg as in the angle bar to take transverse stresses. Thickened fish plates, heat treated and slightly tapered in width from the center bolt holes toward the ends undoubtedly hold the rails in line well while allowing freedom of vertical motion. The present tendency, however, is toward joint bars with horizontal legs of the common angle bar variety. See Joint Bar.

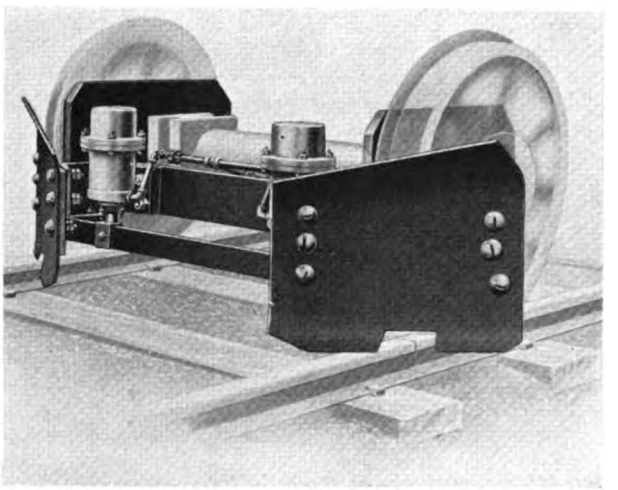
FIXED WING RAIL. The wing rail of a spring rail frog the position of which is stationary as in a rigid frog.

FLANGE CUT. The planing of a portion of the base of a guard rail in a line parallel with the abutting inside edge of the base of the running rail, to allow the guard rail head to be placed at the proper flangeway distance which on straight track is 1¾ in. between the rail heads, measured ⅝ in. below the tops of the rails. See Flangeway. Also Guard Rail.

FLANGE CUT, SWITCH RAIL. The planing at the bottom of the flange of a switch rail which permits the point to lap over and rest on the flange of the stock rail when the point is closed.

FLANGE SEPARATION (Switch). The point of divergence of the flanges of the switch rail and the stock rail of a switch.

FLANGER (Snow). A device for clearing snow away from the gage sides of the running rails of railway tracks. This snow scraper is commonly made of steel plates arranged to depend edgewise from a horizontal cross beam or similar support and so attached to a snow plow, car or locomotive as to permit of being lowered to scrape snow from in front of the wheels to a depth of about 2 in. below the crowns of the running rails; or raised to avoid contact with frogs, switches, stock guards, crossings, etc. Flanger plates are frequently made in pairs, each plate serving one line of running rails.



Ray Snow Flanger
The Q & C Co.
(See Page 776)

They are placed opposite with adjacent inside edges inclined forward and operated together to scrape the snow to the outside of the track. Some flangers are made to operate between the rails only, the plates sometimes being joined to form a wedge plow, or the device consists of one straight plate extending diagonally across the track. One or two-plate types, which are designed to operate on both sides of the rail, have plates notched at the bottoms

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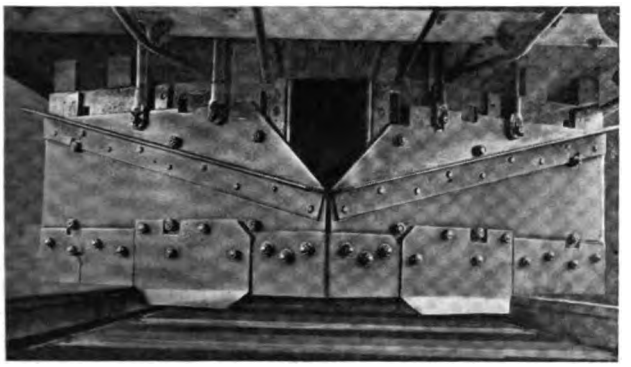
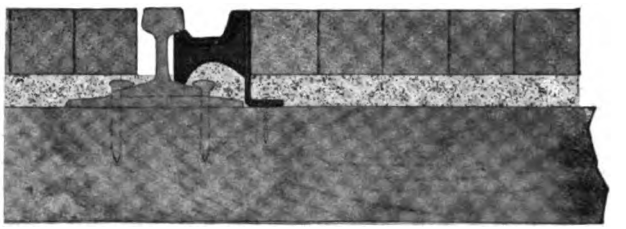
to permit the heads of the rails to come up above the scraping edges, when the device is lowered. Care is taken also to set this edge high enough to clear track joint bolts and nuts. Flangers are raised and lowered by means of rods and levers, usually



Russell Track Flanger
The Russell Car & Snow Plow Co.

operated by compressed air, in order to act quickly and positively while traveling at high speed over tracks containing many obstructions to flangers. Some flanger plates are placed on the outsides of pilot plow wings and operated by hand levers from the locomotive cab. Others are placed close in front of the leading wheels with side plates attaching them to the axle, and connections to an operating lever above the floor line. Standard cars are frequently fitted with flangers and are sometimes used exclusively in snow service. An advantage of the snow flanger is its adaptability to various styles of equipment. Its use is limited to comparatively light snow service and it is not commonly suitable for removing hard snow or ice, especially from the center of the track. See Snow Plow.

FLANGEWAY. The space between the running rail and the guard rail which provides clearance for the passage of wheel flanges, the standard



C. R. S. Flangeway Guard
The Cleveland Railway Supply Co.

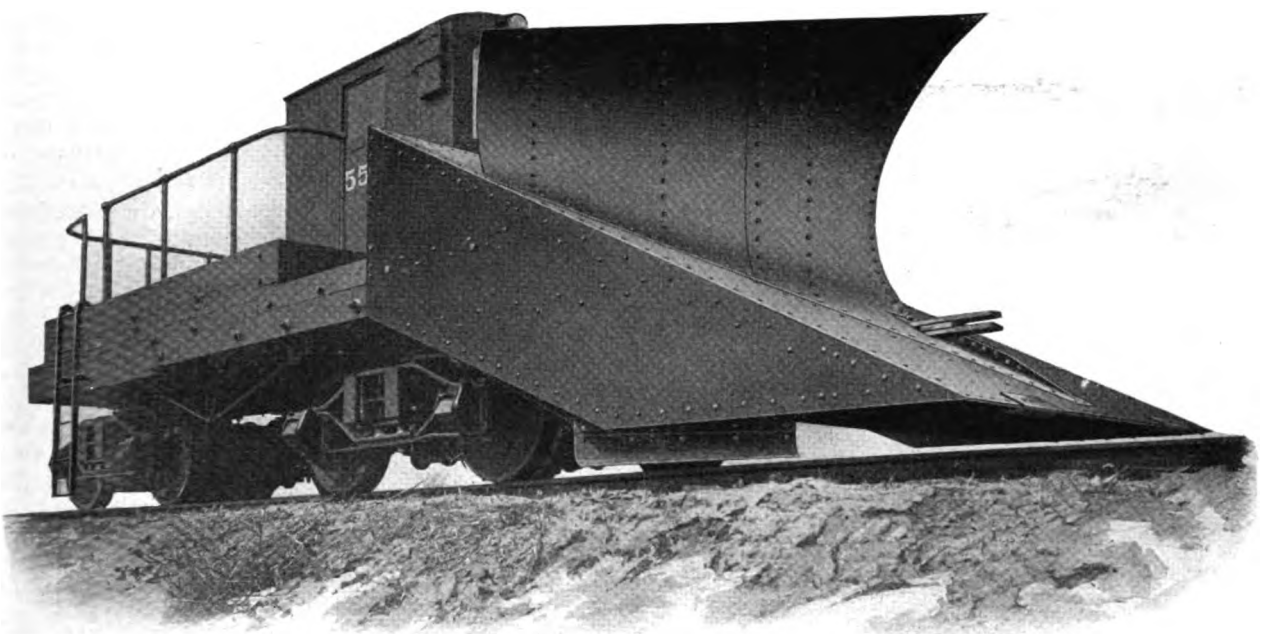
flangeway width on straight track being 1¼ in. while the minimum depth is 1⅞ in. See Guard Rail.

FLANGEWAY DEPTH. The vertical distance of 1⅞ in. from the top of the rail to the bottoms of the grooves in the upper surfaces of the separators introduced between the running rail and the guard rail. See Guard Rail.

FLANGEWAY FILLER. A metal block fastened to and acting as a separator between the webs of the running rail and the guard rail. See Adjustable Separator (Guard Rail).

FLANGEWAY WIDTH. The distance between the gage lines of the main track rail and the adjacent guard rail, measured in a plane ⅝ in. below the top of the rail. The standard flangeway width on straight track is 1¼ in. See Guard Rail. Also Flangeway. Also Frog.

FLARE. A tapered opening of the flangeway formed by inclining the end of a guard rail away from the running rail.



The Ray Snow Plow and Flanger
The Q & C Co.
(See Page 776)

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A flare may be formed by kinking, curving or machining the rail. See Guard Rail.

FLARE BLOCK. See Guard Rail End Block.

FLARE OPENING. The distance between the gage lines of the running rail and the guard rail at the point of maximum opening. See Guard Rail.

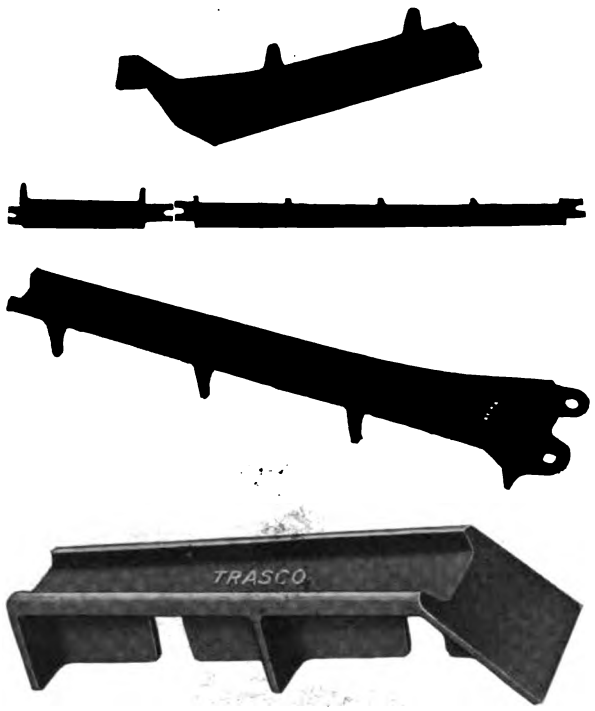
FLAW, RAIL. A defect in the structure of the steel.

FLOW OF METAL (Rail). The rolling out of the steel on the crown of a rail toward the sides of the head without indications of a breaking down of the head structure, the under side of the head showing no distortion.

FOLLOWER. Usually a cast iron cylinder designed to receive the pressure of a coil spring. In spring frogs the coil spring is held in place by a follower block on each end of the spring bolt. See Frog, Spring Wing Rail.

FOLLOWER BLOCK. See Spring Follower.

FOOT GUARD. A filler, preferably of metal, designed to be used to so occupy the space between a stock rail and a guard rail or between the converging heads of the rails of any track device, as a frog, a switch, etc., as to prevent the feet of persons from becoming accidentally wedged between the rails. The



Four Types of Metal Foot Guards

space between two parallel rails set close together or between two converging rails is made as safe as possible for pedestrians by foot guards which fill the flangeway to about the height of the under side of the rail heads. The guard rail foot guard also acts as a separator to maintain the standard flangeway distance between the stock rail and the guard rail.

FROG. A rail-crossing device consisting of two sets of guarded intersecting running rails with flangeways at the intersection which permit wheel flanges to pass freely across either running rail, the tread of the wheel always having a surface on which to roll and the flange of the wheel having a continuous channel through which to pass.

Frogs are built of carbon steel rails, of carbon steel rails combined with manganese steel castings, of manganese rolled rails and of solid manganese castings. They were for many years made exclusively of carbon steel rails and this type still predominates, especially where traffic conditions are not severe. The carbon steel rail is commonly available and comparatively easy to convert into frogs, while extended experience has developed a high standard of manufacture. Renewals of worn parts are commonly made by railway employees, thus increasing the service life of the frog, usually without shipping it beyond the nearest division point for repairs. More recently the practice has developed of restoring the worn parts to their original section by means of modern portable welding devices without removing the frog from the track.

Since about 1900 manganese steel has come into use as a frog material. Its marked resistance to abrasion and impact when either cast or rolled, has led to its adoption in the construction of frogs for installation at points of heavy service where it commonly outwears four or five and sometimes ten frogs of carbon steel rail construction. In tracks carrying moderately heavy traffic, present practice favors its limitation to the wearing parts in carbon steel rail frogs, as the tongue and throat of turnout frogs, owing to the relatively high cost of manganese steel, the body of the frog being frequently made of a single manganese casting surrounded by rails of carbon steel. Such frogs are known as manganese-insert, manganese-center, manganese-body, or rail-bound-manganese frogs. Such construction possesses the advantage of the longer life of the manganese steel at a comparatively small increase in cost over that of the carbon steel rail frog.

Where the service is severe frogs are sometimes built of rolled manganese steel rails. The advantage of this construction is the economy and facility with which repair parts may be installed, frequently without removing the frog from service. A more common form of construction at points of heavy wear is the manganese cast frog which is favored for use in freight yards where curves are sharp, where axle loads are heavy and where switching movements are numerous. The single manganese casting acts as a unit, there are no fastenings to maintain and the service life is extended. Its chief limitation has arisen from conditions inherent in manufacture and not unusual in the use of high priced alloy steel devices, adaptable to combinations with lower priced materials. As a result manganese steel construction has been confined generally to short, wide frog castings.

In respect to the purposes for which they are used, frogs are classed as turnout frogs and crossing frogs.

Turnout Frog

A turnout frog is a rail-crossing device consisting of two sets of guarded intersecting running rails with flangeways at the intersection which permit wheel flanges to pass freely across the rail of

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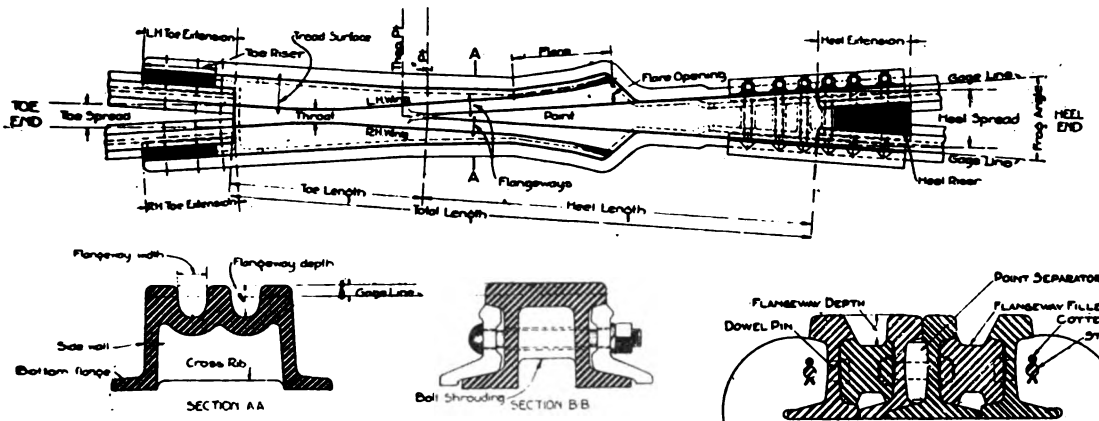
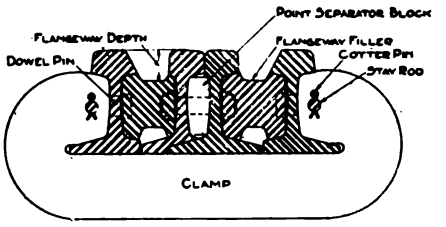
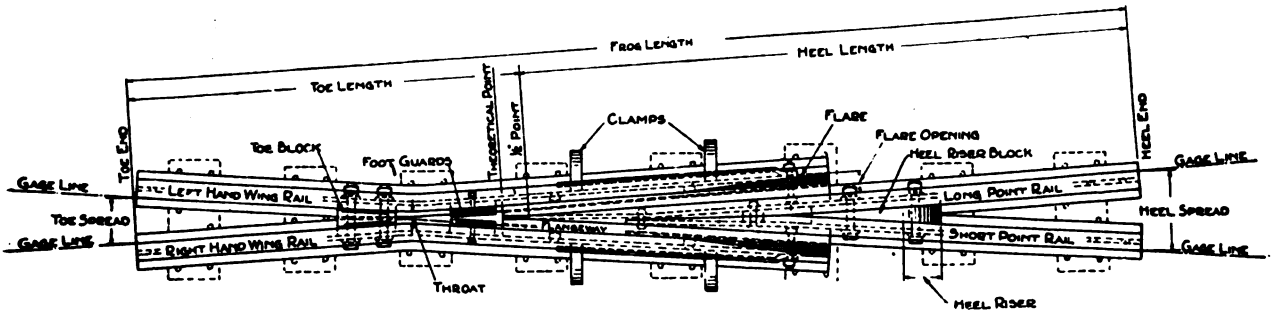


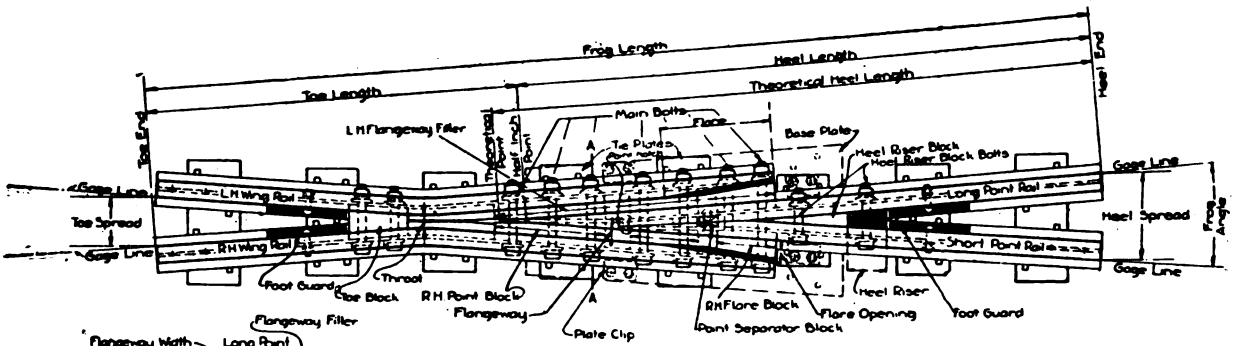
A. R. E. A. Manganese Cast Frog Showing Names of Parts



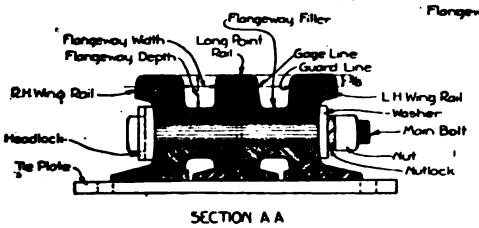
SECTION THROUGH CLAMP

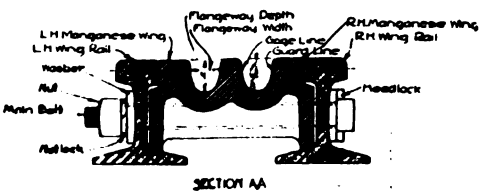


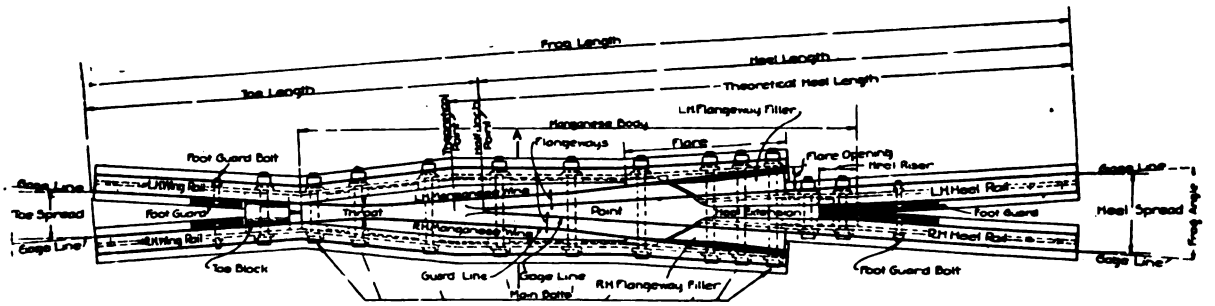
A. R. E. A. Clamp Frog Showing Names of Parts



A. R. E. A. Bolted Rigid Frog Showing Names of Parts







A. R. E. A. Rail Bound Manganese Frog Showing Names of Parts

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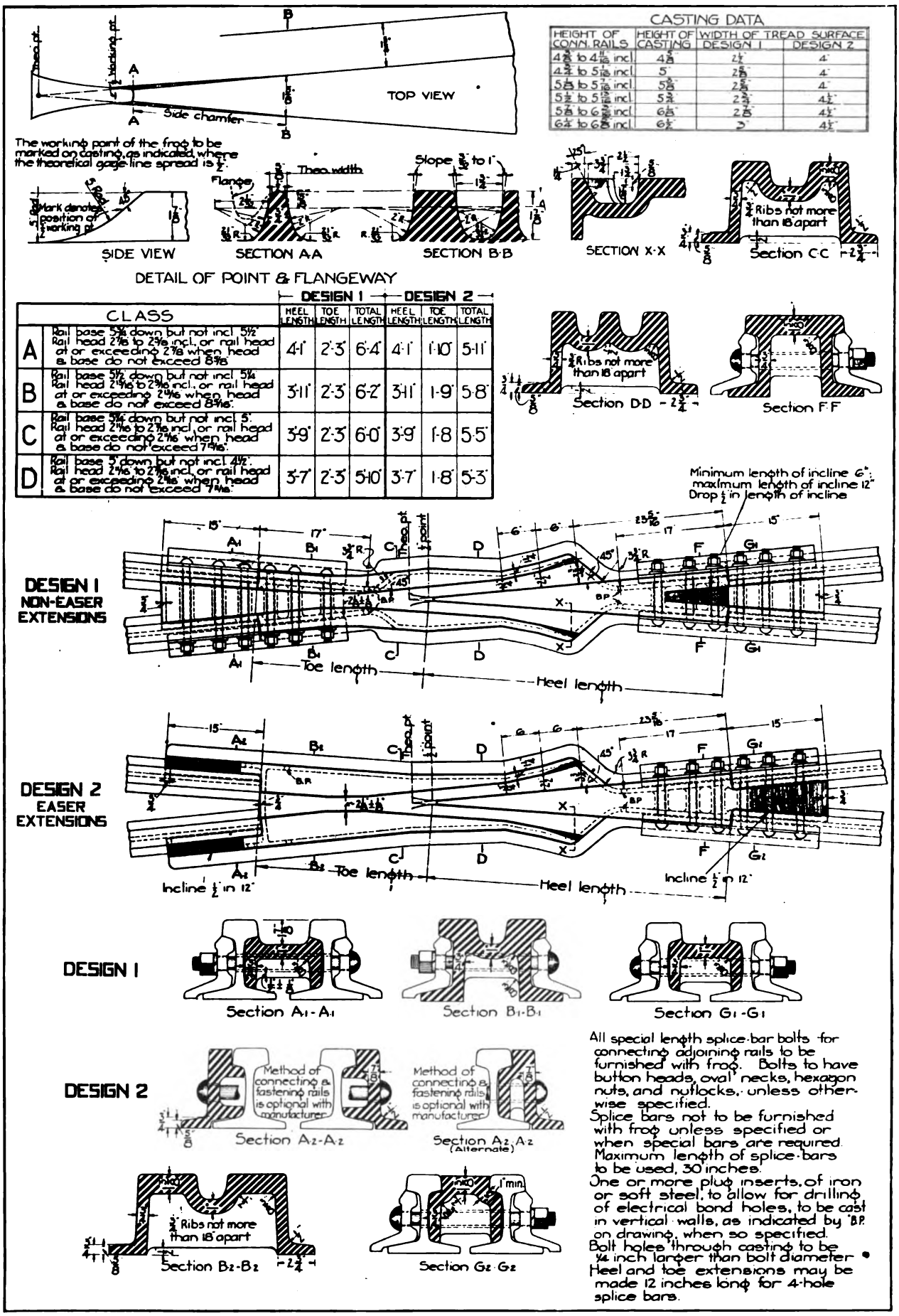

CLASS		DESIGN 1 HEEL LENGTH	DESIGN 1 TOE LENGTH	DESIGN 1 TOTAL LENGTH	DESIGN 2 HEEL LENGTH	DESIGN 2 TOE LENGTH	DESIGN 2 TOTAL LENGTH
A	Rail base 5 1/16" down but not incl. 5 1/2". Rail head 2 7/8" to 2 15/16" incl., or rail head at or exceeding 2 7/8" when head & base do not exceed 8 5/8".	4'-1"	2'-3"	6'-4"	4'-1"	1'-10"	5'-11"
B	Rail base 5 1/16" down but not incl. 5 1/4". Rail head 2 7/16" to 2 9/16" incl., or rail head at or exceeding 2 1/16" when head & base do not exceed 8 5/16".	3'-11"	2'-3"	6'-2"	3'-11"	1'-9"	5'-8"
C	Rail base 5 1/16" down but not incl. 5". Rail head 2 1/16" to 2 1/16" incl., or rail head at or exceeding 2 1/16" when head & base do not exceed 7 15/16".	3'-9"	2'-3"	6'-0"	3'-9"	1'-8"	5'-5"
D	Rail base 5" down but not incl. 4 1/2". Rail head 2 1/16" to 2 1/16" incl., or rail head at or exceeding 2 1/16" when head & base do not exceed 7 1/16".	3'-7"	2'-3"	5'-10"	3'-7"	1'-8"	5'-3"

A. R. E. A. Standard No. 6 Frogs of Solid Manganese Steel

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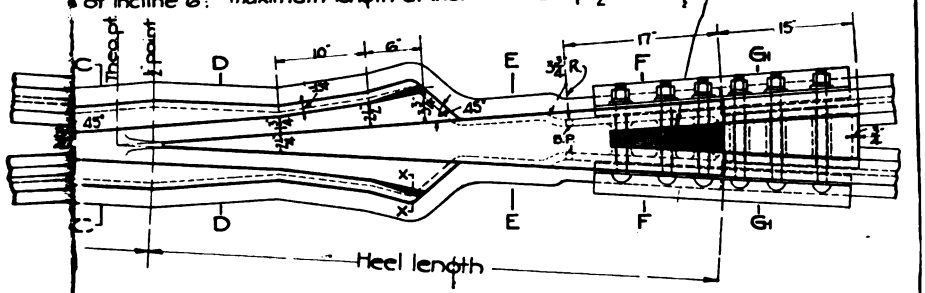
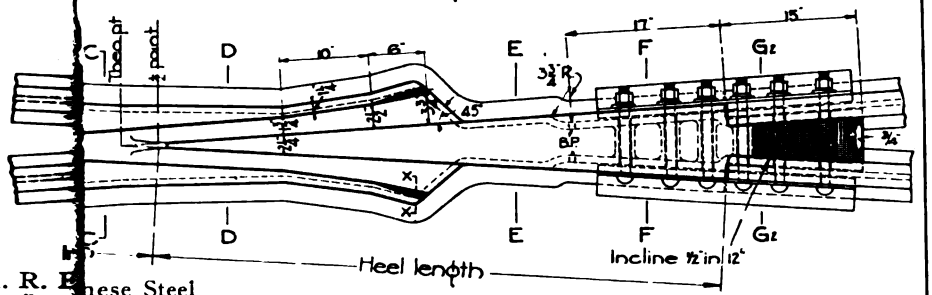
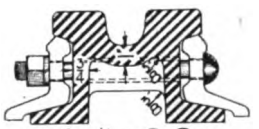
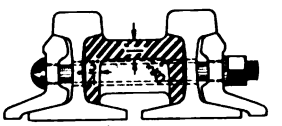
of incline 6". maximum length of incline 12" Drop ½ in length of incline.

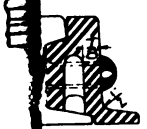


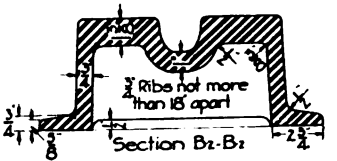


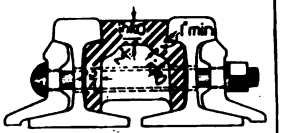
A. R. E. ...nese Steel
Steel ...nsions

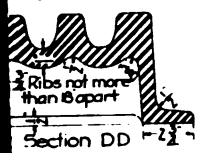


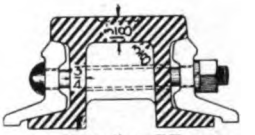




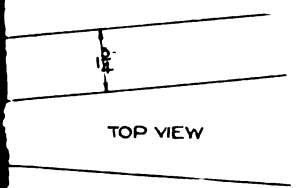






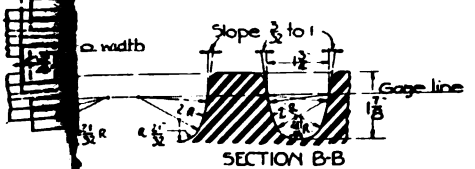


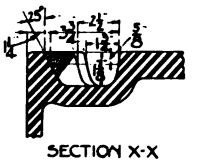
Incline ½" in
A. R. E.



CASTING DATA

HEIGHT OF CONN RAILS	HEIGHT OF CASTING	WIDTH OF TREAD SURFACE DESIGN 1	DESIGN 2
4⅞ to 4 11/16 incl	4⅞	2½	4"
4¾ to 5⅛ incl	5"	2⅞	4"
5⅛ to 5 5/16 incl	5⅛	2⅞	4"
5⅜ to 5 5/16 incl	5⅜	2⅞	4½"
5⅝ to 6⅜ incl	6⅛	2⅞	4½"
6¼ to 6⅜ incl	6½	3"	4½"





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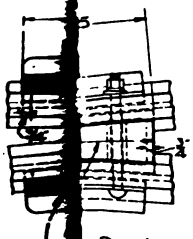

CLASS		DESIGN 1 HEEL LENGTH	DESIGN 1 TOE LENGTH	DESIGN 1 TOTAL LENGTH	DESIGN 2 HEEL LENGTH	DESIGN 2 TOE LENGTH	DESIGN 2 TOTAL LENGTH
A	Rail base 5⅜ down but not incl. 5½". Rail head 2⅛ to 2⅜ incl. or rail head at or exceeding 2⅛ when head a. base do not exceed 8⅜ lbs.	4'-9"	2'-5"	7'-2"	4'-9"	2'-1"	6'-10"
B	Rail base 5⅛ down but not incl. 5¼". Rail head 2⅛ to 2⅜ incl. or rail head at or exceeding 2⅛ when head a. base do not exceed 8 lbs.	4'-7"	2'-5"	7'-0"	4'-7"	2'-0"	6'-7"
C	Rail base 5⅛ down but not incl. 5". Rail head 2⅛ to 2⅜ incl. or rail head at or exceeding 2⅛ when head a. base do not exceed 7⅞ lbs.	4'-4"	2'-5"	6'-9"	4'-4"	1'-11"	6'-3"
D	Rail base 5" down but not incl. 4⅝". Rail head 2⅛ to 2⅜ incl. or rail head at or exceeding 2⅛ when head a. base do not exceed 7⅞ lbs.	4'-2"	2'-5"	6'-7"	4'-2"	1'-10"	6'-0"

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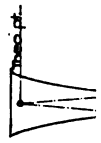

The working
marked on
the theoretical

A	Rail
B	Rail
C	Rail
D	Rail

DESIGN
NON-EASE
EXTENSIO

DESIGN
EASER
EXTENSIO

DE

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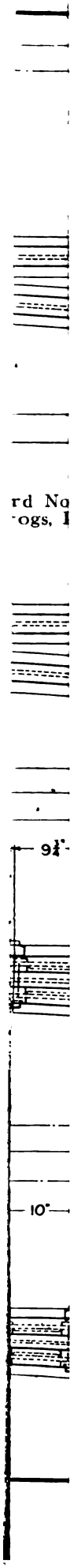

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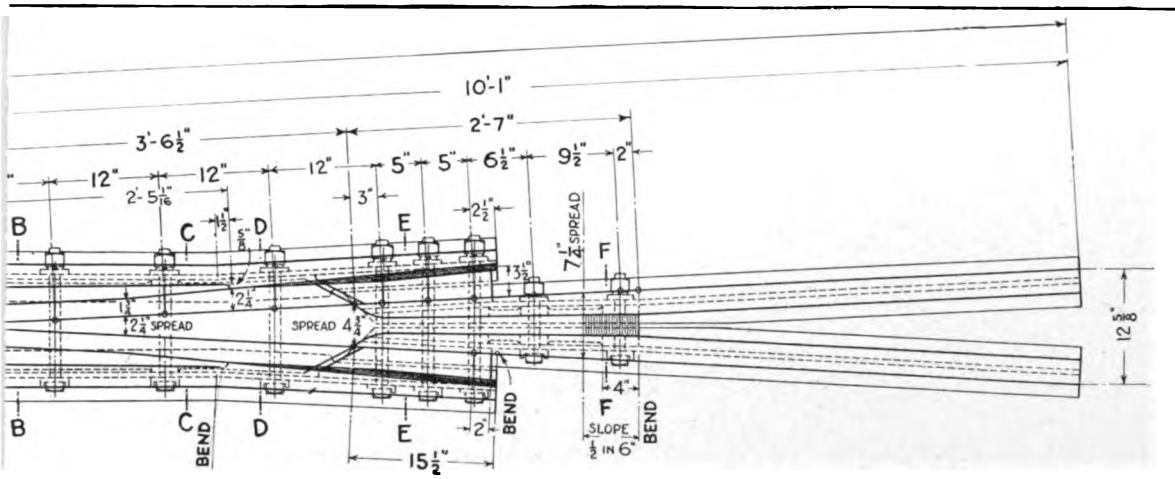
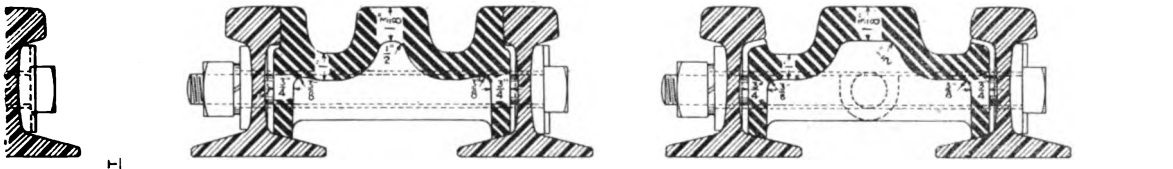
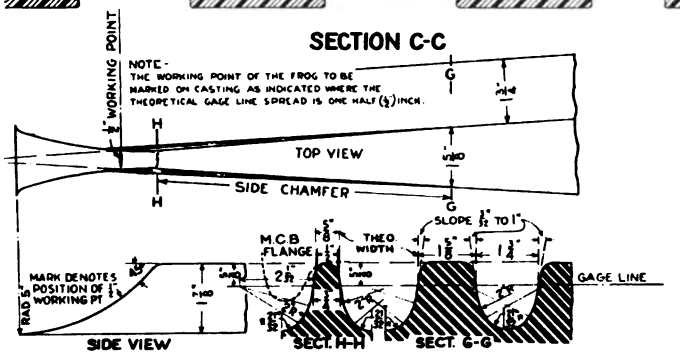


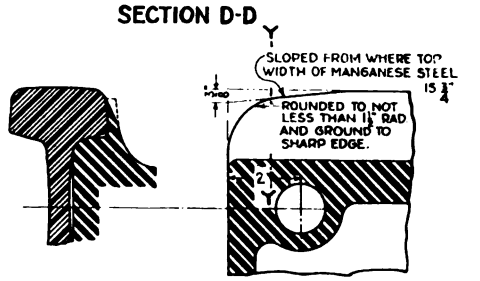


SECTION C-C

SECTION D-D

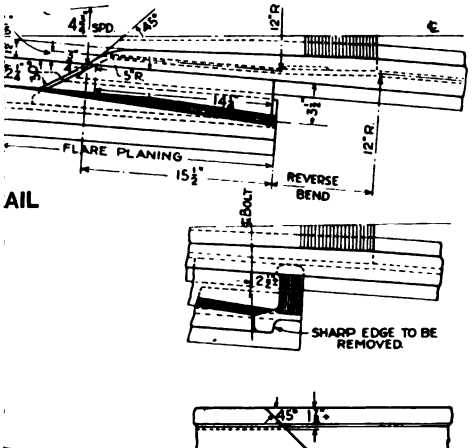


DETAIL OF POINT AND FLANGEWAY



SECTION Y-Y

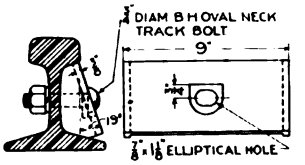
LONGITUDINAL SECTION X-X



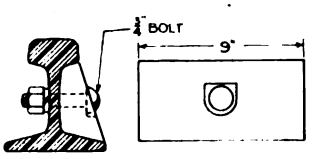
AIL

IF

DETAIL OF BEVELED WING RAIL (OPTIONAL)



METAL FOOT GUARD.



OAK WOOD FOOT GUARD.

SPECIFICATIONS.

BOLTS.- THROUGH BOLTS 1¼" DIA FOR 120 LB RAIL AND HEAVIER
1⅛" DIA BOLTS FOR RAILS LESS THAN 120 LB AND DOWN TO RAILS HAVING 3" FISHING HEIGHT
1" DIA BOLTS FOR RAILS HAVING LESS THAN 3" FISHING HEIGHT DOWN TO, AND INCLUDING 80 LB RAIL.
FISHING HEIGHT SHALL BE MEASURED ON VERTICAL CENTER LINE OF RAIL
THROUGH BOLTS TO BE OF HIGH TENSILE STEEL.

THROUGH BOLTS.- TO HAVE SQUARE HEADS AND NUTS WITH U.S. STANDARD THREAD, FITTED WITH HEAD LOCKS, NUT LOCKS AND BEVEL WASHERS WHERE NECESSARY TO AFFORD SQUARE BEARING.
SUITABLE WASHERS IN ANY CASE, SHALL BE PLACED UNDER NUTS, TO BRING SAME OUT FROM UNDER HEAD OF RAIL, SO THAT THEY MAY BE TIGHTENED WITH STANDARD WRENCH.

FILLERS.- FILLERS BETWEEN HEEL RAILS AND WING RAILS TO BE OF A SUITABLE STANDARD ROLLED STEEL DOUBLE OR SINGLE GROOVE SECTION, OR CAST IRON SINGLE GROOVE SECTION. TOE BLOCK TO BE OF CAST IRON

PLATES.- TIE PLATES WHEN REQUIRED SHALL BE AS PER PLAN Nº 305.

LENGTHS.- LENGTHS OF FROGS OVER ALL SHALL NOT VARY MORE THAN ¼" FROM LENGTH SPECIFIED, FROGS MAY BE FURNISHED TO MODIFIED LENGTHS TO MEET ALIGNMENT OF TRACK OR LOCAL CONDITIONS WHEN SPECIFIED

FOOT GUARDS.- ADDITIONAL FOOT GUARDS TO BE FURNISHED WHEN SO SPECIFIED

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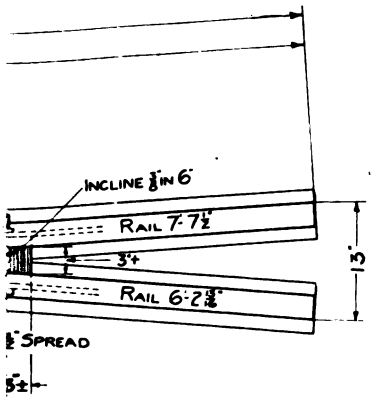
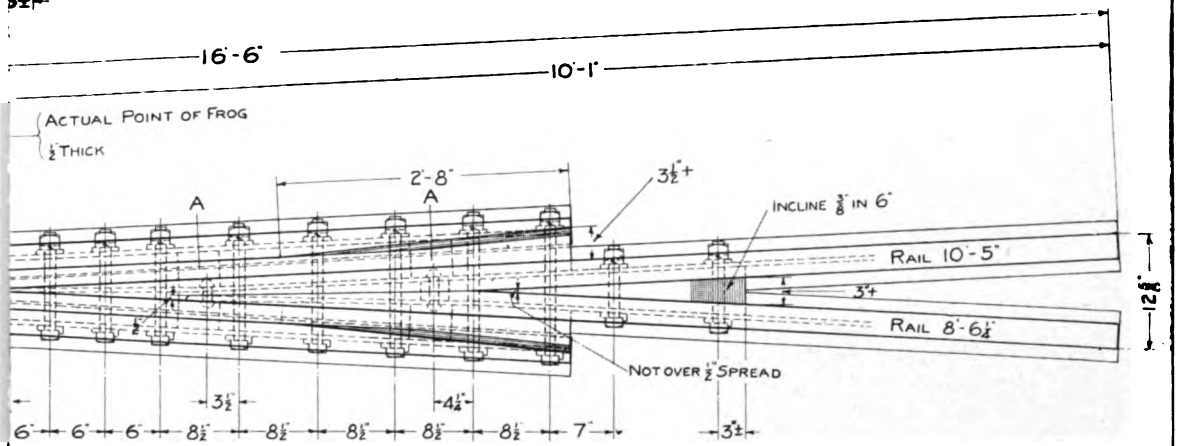


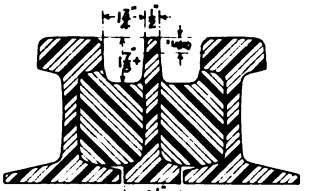
SPECIFICATIONS :–

BOLTS.– Through Bolts 1⅜" dia. for 120 lb. Rail and heavier.
1¼" dia. bolts for Rails less than 120 lb and down to Rails having 3" Fishing Height.
1⅛" dia. bolts for Rails having less than 3" Fishing Height, down to and including 80 lb Rail.
Fishing Height shall be measured on Vertical Center Line of Rail.
All Through Bolts, including those in Heel Riser Block, to be Heat Treated Steel, and to have an Elastic Limit of not less than 70,000 lbs. per square inch and to stand cold flat Bending Test through 180° without fracture.
All Through Bolts to have tight fit and Extra Thick Nuts.
Through Bolts to have Square Heads and Nuts with U.S. Standard Thread, fitted with Head Locks, Nut Locks and Bevel Washers where necessary to afford square bearing.
Suitable Washers in any case shall be placed under nuts to bring same out from under Head of Rail so that they may be tightened with a standard wrench.

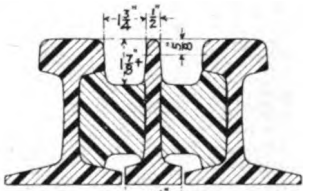
FILLERS.– Filler Blocks shall fit the Fishing Angles and the Web of Rail for a distance of ½" from above and below the Base and Head respectively, and shall maintain the required Flangeway.
Throat Filler Block and Point Seperator Blocks shall be of good quality Grey Cast Iron Body Filler Blocks shall be of Rolled Steel in one continuous length either single or double groove section, or of good quality Grey Cast Iron when specified, in which case they shall be furnished of single groove section and in three lengths with open spaces A as indicated by dotted lines.



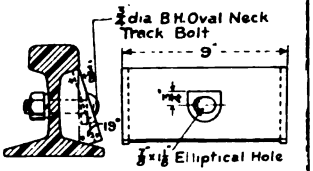
T BLOCK



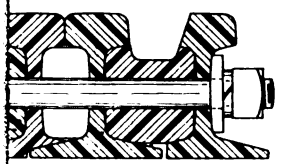
SECTION AT ½" POINT
SINGLE GROOVE FILLER



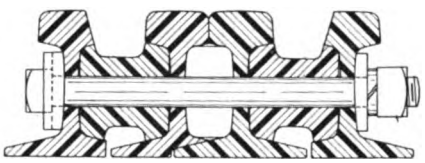
SECTION AT ½" POINT
DOUBLE GROOVE FILLER



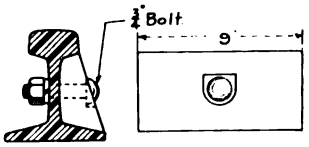
METAL FOOT GUARD



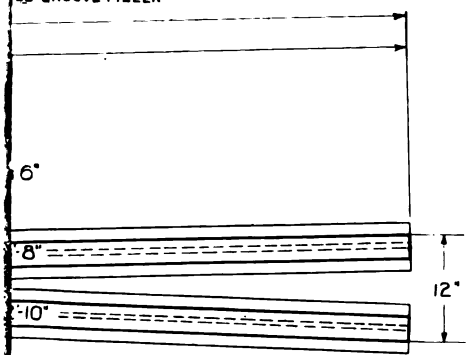
EPARATION OF RAIL HEADS
LE GROOVE FILLER



SECTION NEAR SEPARATION OF RAIL HEADS
DOUBLE GROOVE FILLER



OAK WOOD FOOT GUARD



HEEL RISER.– Heel Riser shall be of Steel Rail, Head up with Flange upset to properly fit over and rest upon Bases of adjoining Rails or of other approved Design that will insure a proper bearing on the Bases of the Heel Rails and will provide Rolled or Forged Steel Wearing Surface equal in hardness to Rail Steel.

RIVETS.– Rivets through Point Rails shall be ¼" less in diameter than the through Bolts. They may be Countersunk. If either Button or Cone Head Rivets are used, Filler Blocks must be cut out to clear.

PLATES.– Bearing Plates when required shall be as per Plan No. 308.

LENGTHS.– Lengths of Frogs overall shall not vary more than ¼" from Length Specified. Frogs may be furnished to modified Lengths to meet Alignment of Track or Local Conditions when Specified.

FOOT-GUARDS.– Additional Foot Guards to be furnished when so specified.

BEVELED ENDS OF WING RAILS.– Flared end of Wing Rails may be beveled on an angle of 45° as per detail when so specified.

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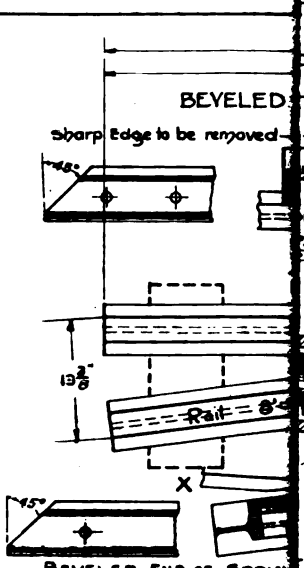
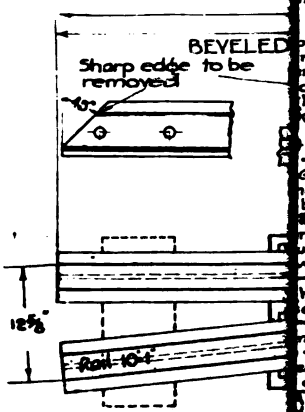
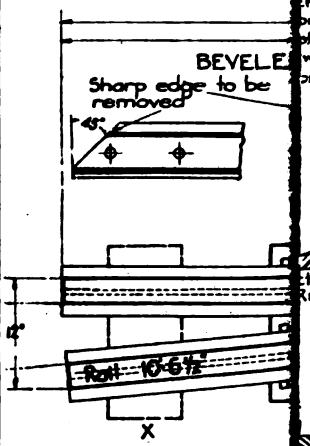
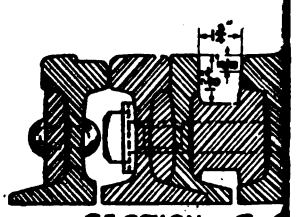
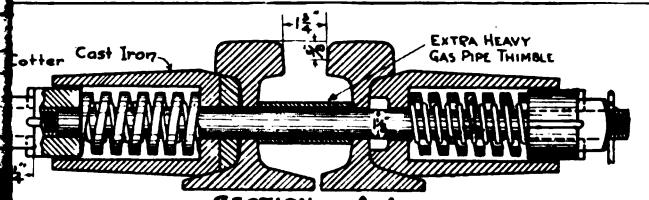


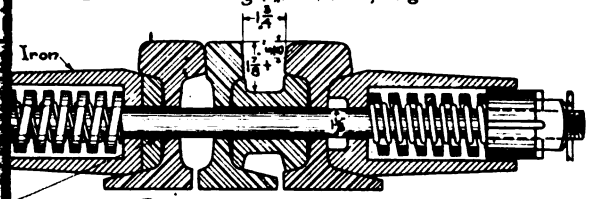








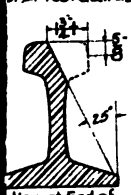
utside Coil- 2½" out. dia. ⅜" Sq. steel.- 7½ Free coils. Inner Coil 1 11/16" out. dia. ¼" r'd.
steel- 10 Free coils. Length when Free 5"- Or Single Coil Spring. 2 5/16" out. dia.
" r'd.- 6½ Free Coils. Length when Free, 4 3/8"

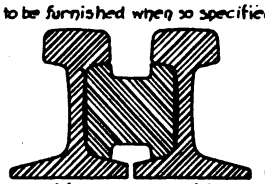


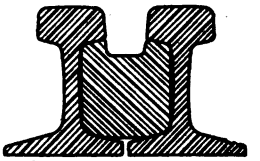
hole in Spring Rail for Spring Bolt to be 1¼" high
long. (When Spring is used in Alternate position.)

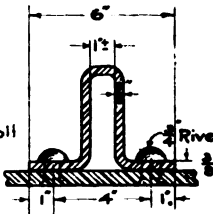
SPECIFICATIONS.

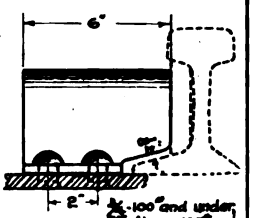
hrough bolts 1⅜" dia. for 120 lb. rail and heavier 1¼" dia. bolts for rails less than
nd down to rails having 3" fishing height, 1⅛" dia. bolts for rails having less than 3"
height, down to and including 80 lb. rail.
height shall be measured on vertical center line of rail.
ough Bolts including those in heel riser block to be Heat Treated Steel and to
n Elastic Limit of not less than 70,000 lbs. per sq. inch, and to stand a cold
nding test through 180° without Fracture.
ough Bolts to have a tight fit, and extra thick nuts.
h Bolts to have Square heads and Nuts with U.S. Stand. Thread, fitted with Head Locks,
rs and Bevel Washers where necessary to afford a Square bearing. Suitable Washers
case shall be placed under nuts to bring same out From under head of Rail
they may be tightened with a standard wrench.
— Main Fillers shall be of rolled steel in one continuous length, either Single or
Groove section, and shall maintain the required Flangeway throughout.
hust Fit the fishing angles and the web of rail for a distance of ½" above base
below head. Point separator Blocks shall be of good quality grey cast iron.
ER— Heel Riser shall be of Steel Rail, head up, with Flange upset to properly
r and rest upon bases of adjoining rails or of other approved design that
ure a proper bearing on bases of heel rails and will provide Rolled or Forged
wearing surface equal in hardness to Rail steel.
— Rivets through point rails shall be ¼" less in diameter than the
h Bolts. They may be countersunk. If either Button or Cone head rivets
ead, Filler must be cut out to clear. All rivets through Base Plates to be ¾" dia.
— For Rails over 100 lbs. per yard, Plates to be ¾" x 8", and for Rails 100 lbs. per
nd less, ⅝" x 8". Length as required.
— Lengths of Frogs overall shall not vary more than ¼" from length
ed. Frogs may be furnished to modified lengths to meet alignment of
or local conditions when specified.
TES — Spring may be placed 14" back of actual point as shown by
line. Loose plates marked X, punched to match angle bar slotting
Furnished only when specified.
tie base plate as indicated by dotted lines may be furnished
specified.
Point Rail may be placed on opposite side of Frog when specified.
Wood or Metal Foot Guards may be furnished.
re with flat face and nuts without slots may be used on spring bolt; see
ons A-A & B-B
of Wing Rail and Spring Wing Rail may be beveled on an angle of 45° as per
when so specified.
onal Foot Guards to be furnished when so specified.



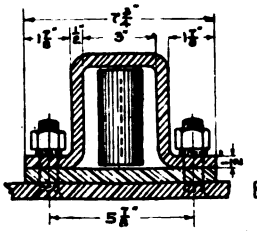

Double Groove Filler.

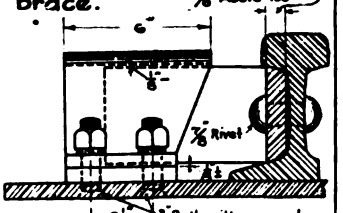

Single Groove Filler.





Brace.





Hold Down.

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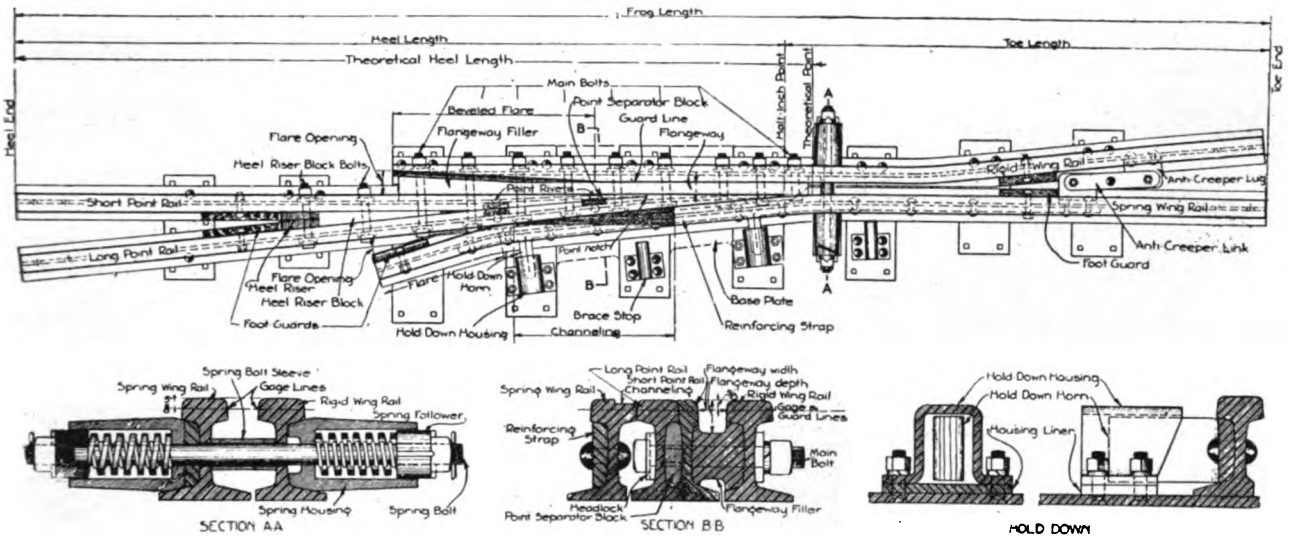
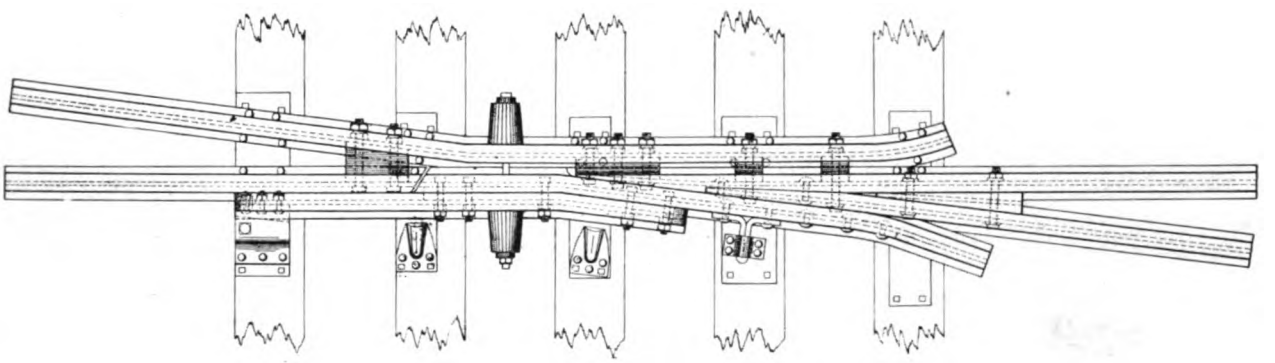
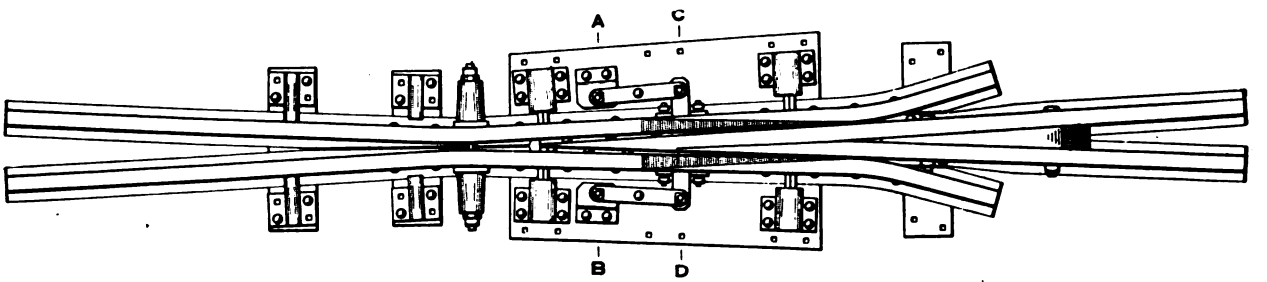


A. R. E. A. Standard Spring Rail Frog Showing Names of Parts



Hinged Spring Rail Frog
The Frog and Switch Mfg. Co.



Double Spring Rail Frog
The Morden Frog & Crossing Works

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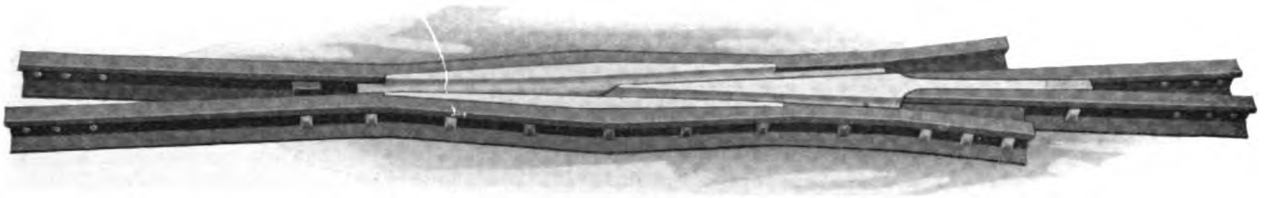
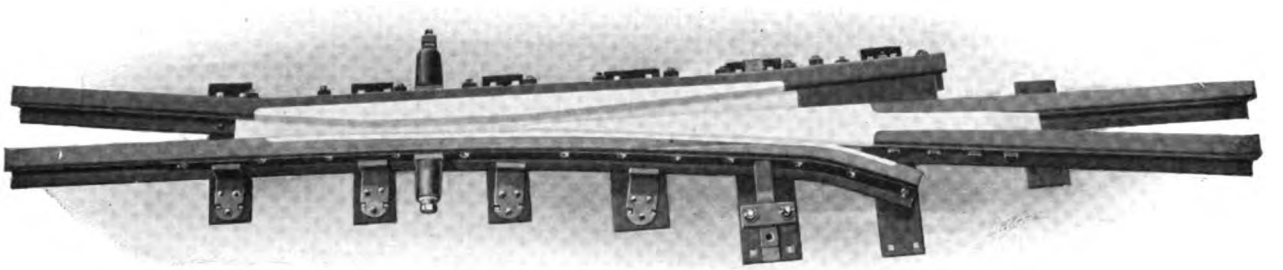
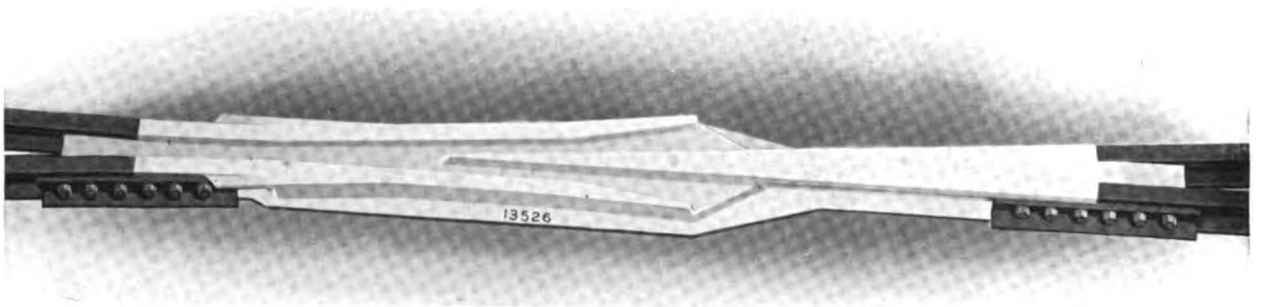
Double Pointed Frog with Manganese Center



Manganese Rail Bound Rigid Frog



Manganese Rail Bound Spring Rail Frog



Solid Manganese Steel Frog

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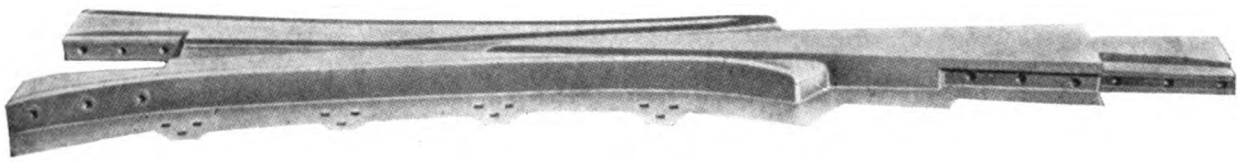
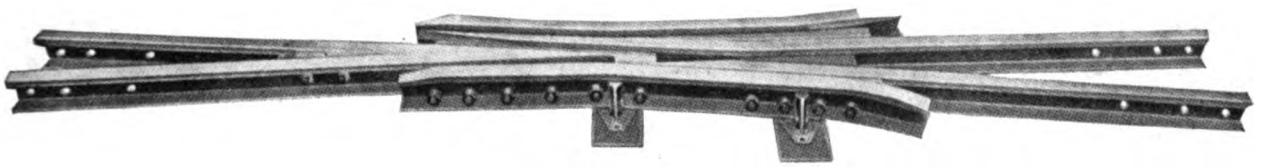
either the parent track or the turnout track, the tread of the wheel always having a surface on which to roll and the flange of the wheel having a continuous channel through which to pass.

The angles of the frogs in general use in turnouts vary from three degrees to ten degrees. A frog is commonly designated by a number determined by dividing the distance of any point from the point of the frog by the spread at that point. Theoretically, the frog number is one-half the cotangent of one-half the angle of the frog. According to A. R. E. A. specifications the manufacturer is required to stamp in raised letters and figures ¾ in. high on the flare of the wing rail, the number of the frog, the date of manufacture, the weight per yard of the rail and the manufacturer's name. To eliminate multiplicity of designs, three numbers of frogs, No. 8, No. 11, and No. 16, have been recommended by the A. R. E. A. as meeting all general requirements for yards, main track switches and junctions.

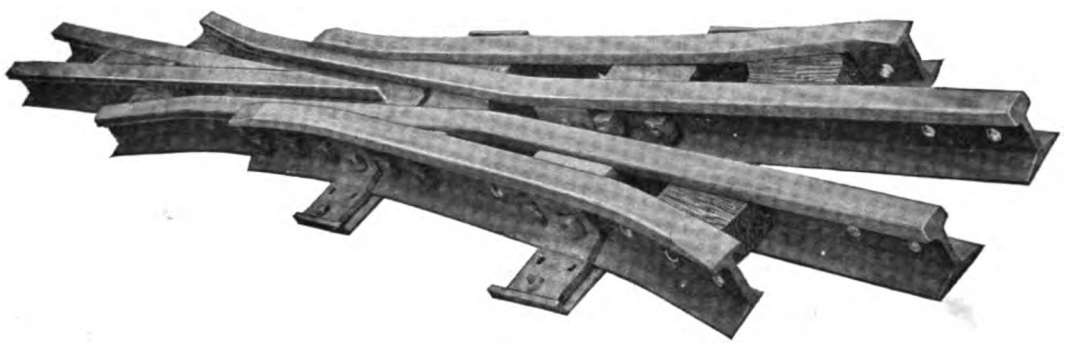


Conley Flanged Frog of Manganese Steel
The Conley Frog and Switch Co.



Conley Flanged Rail Frog
The Conley Frog and Switch Co.

Graham Solid Manganese Flanged Frog
The American Flange Frog & Railway Improvement Co.
(See Page 633)



Graham Flanged Rail Frog
The American Flange Frog & Railway Improvement Co.
(See Page 633)

The point of a rail turnout frog is formed by planing the long point rail at the desired angle to a point over the web and by cutting a notch into the planed side of the head a short distance back of the point, into which the short point rail fits after also being planed to the proper angle; so that

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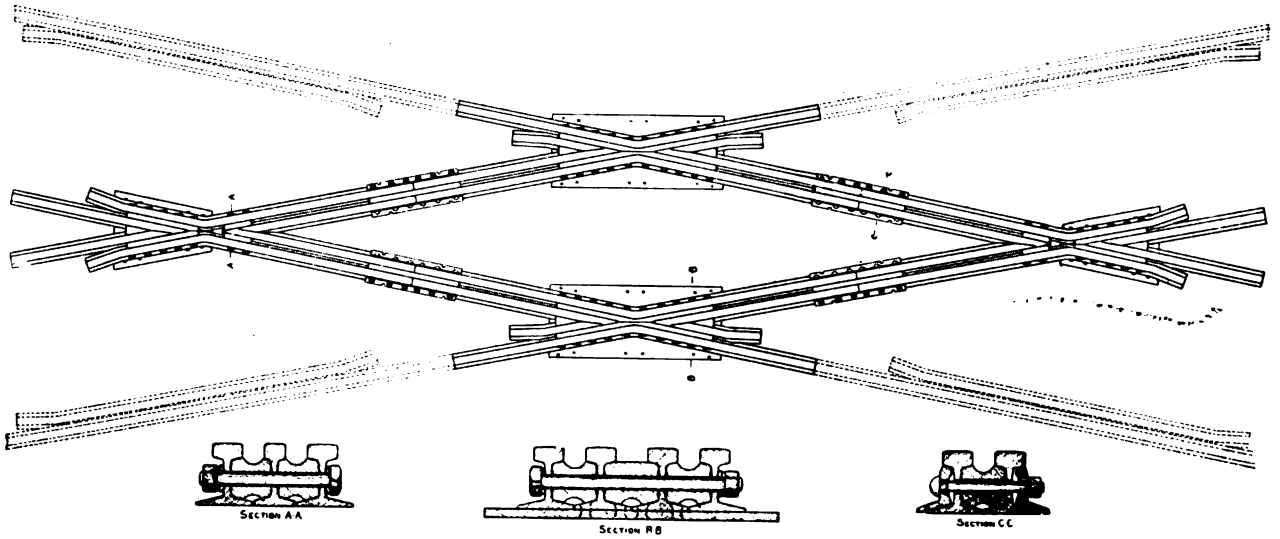
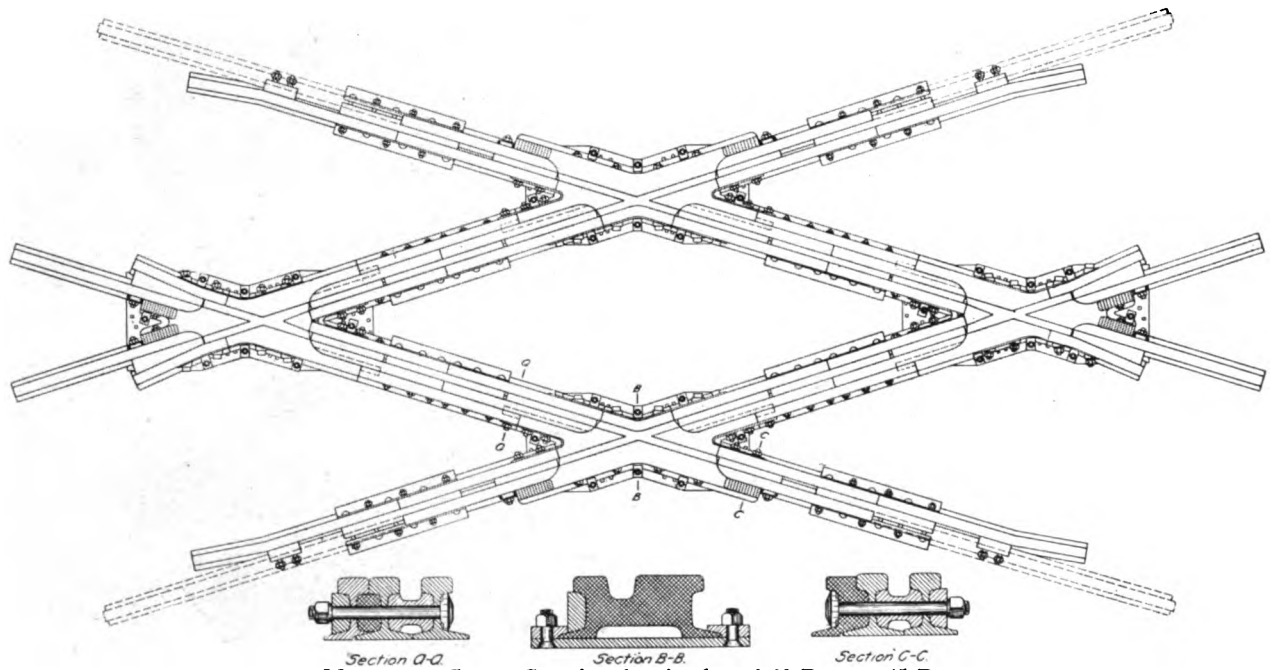
the angle of divergence of the frog is represented by the gage lines of the point rails, which are riveted together through the planed surfaces. As it is not practicable to manufacture a frog point to extend to the apex of the frog angle, known as the theoretical point of the frog, the point at which the divergence is ½ in., known as the actual point, is that commonly adopted in construction.

An early and simple type of rigid, bolted, rail frog consists of a pair of point rails riveted together near their intersection, two wing rails, two point filler blocks and the necessary main bolts to hold the parts in the correct relative positions. Such a frog is used only for light traffic tracks. As the service to which frogs are subjected has become increasingly severe, the construction has been



Bolted Plate Crossing for Angles of 20 Deg. to 25 Deg.



Manganese Center Crossing for Angles of 30 Deg. to 45 Deg.

Turnout frogs are divided into two principal classes: rigid frogs and movable wing frogs. A rigid frog is without movable parts and provides two intersecting, fixed, open flangeways. Therefore, it is used commonly in turnouts involving tracks carrying approximately equal traffic. Though it is the standard form of construction for main track turnouts on some heavy traffic freight lines, its use is most generally confined to turnouts in secondary tracks, such as yard and industrial tracks. It is a sturdy type, comparatively inexpensive to manufacture and maintain.

strengthened until the rigid rail frog now in general use commonly has several extensive flangeway fillers, a steel base plate and tie plates to which the frog rails are riveted or fastened with pinch plates, a heel riser block to guard against worn wheel flanges wearing down or splitting the point rails apart, and foot guard devices. A still more recent design is the clamped frog in which two special forged iron or steel clamps take the place of the main bolts between the point of the frog and the flare of the wing rails. These clamps extend under and around the frog rails, the ends of the clamps

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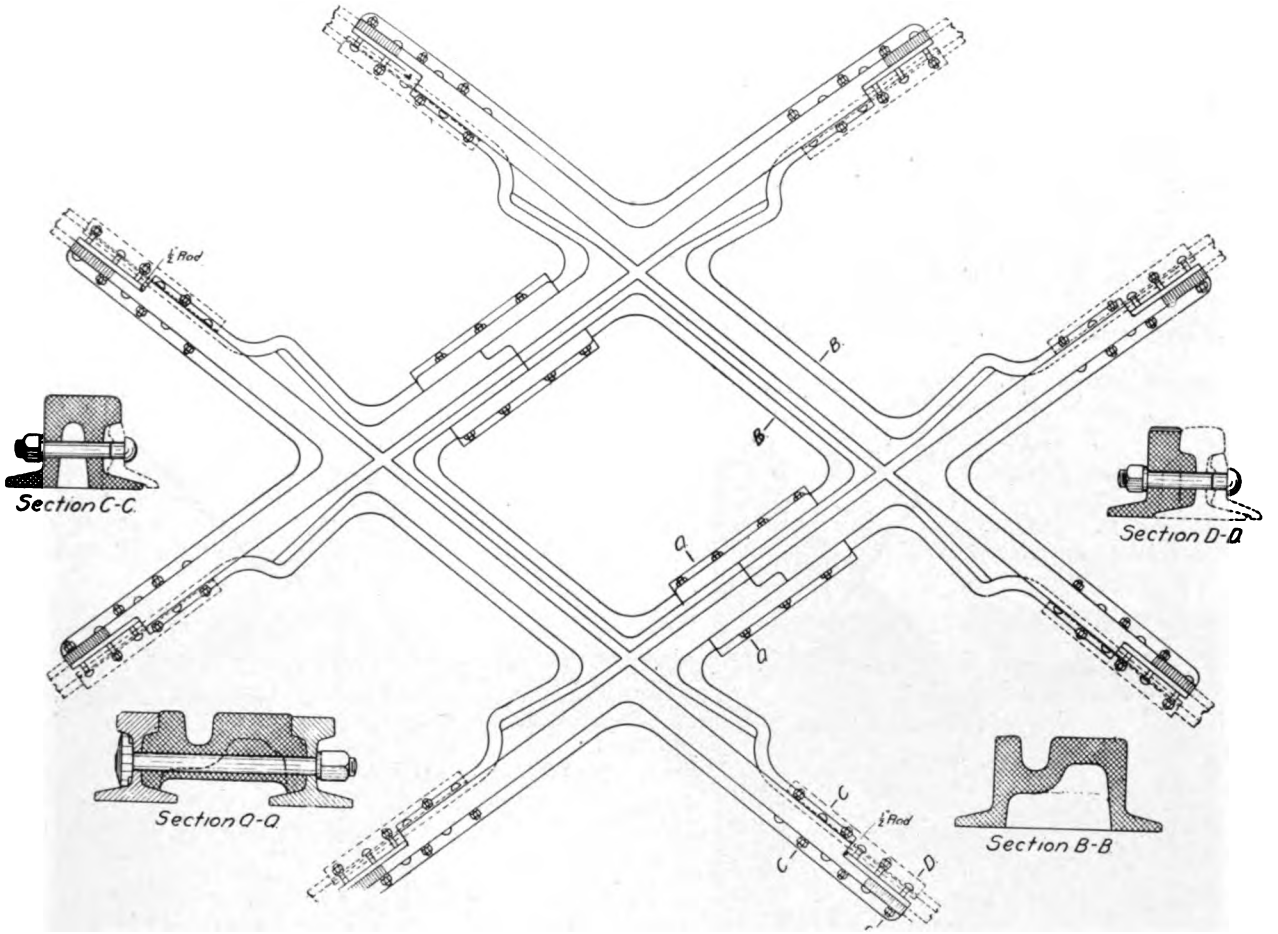
curving up to the webs of the outside rails where they are wedged into place by means of metal blocks, keys and fasteners.

The fixed open flangeways of a rigid frog present channels which the wheels must cross, so that it is not a smooth riding device. Also the movement of the wheels across these open channels causes a pounding of the frog, which results in rapid wear at the flangeways. Where most of the traffic is over one track, as in main line turnouts, a rigid frog will wear unequally. For these reasons it has been generally superseded by the movable wing frog for main line turnouts on fast traffic lines.

A movable wing frog is a turnout frog of which one wing rail is normally held tightly against the tongue by a spring or springs (sometimes supplemented by a hinge to prevent the movable wing from being affected by creeping rails), thus closing one flangeway except when flanges are passing through on the turnout track when the spring is compressed and the flangeway is momentarily forced open for the passage of the flanges. In this manner a practically continuous running rail is presented for the parent track.

With the object of maintaining a continuous parent line rail at a turnout, several designs of so-called continuous rail frogs have been devised to lift the rail flange over the parent line rail, to divert it by means of a frog tongue hinged at the back and free to move from rail to rail at its point, or by means of a short section of rail pivoted at the intersection of the parent line and turnout rails and rotating into line with either rail.



Solid Manganese Crossing for Angles of 45 Deg. to 90 Deg.

A further type is the movable point frog commonly used in slip switches, which is in reality a pair of modified switch points or pointed rails. Still another type is the crotch frog that is used at the intersections of outside turnouts of three-way switches, and at turnouts from curved track where the turnout curve is in the direction opposite to and of about the same degree as the main track curve. In order to eliminate the use of separate guard rails, frogs are designed with raised flanges or with flange rails that are higher than the wing rails, ahead of and extending a few inches back of the frog point, to guide the wheels in their proper course. Where it is imperative to so place two turnouts that the guard rails intersect, a double-pointed frog is sometimes used; the guard rails in such cases being combined into one continuous guard rail protecting two frogs, the points of which face each other. A double-pointed frog and a single pointed frog are

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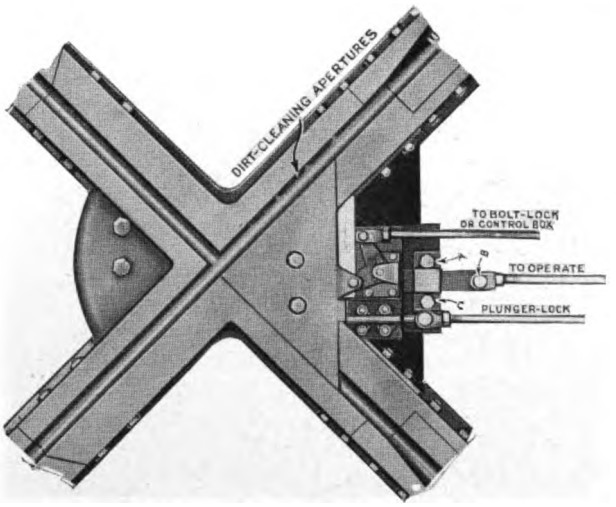


Eymon Continuous Rail Crossing Frog
The Eymon Crossing Co.
(See Page 685)

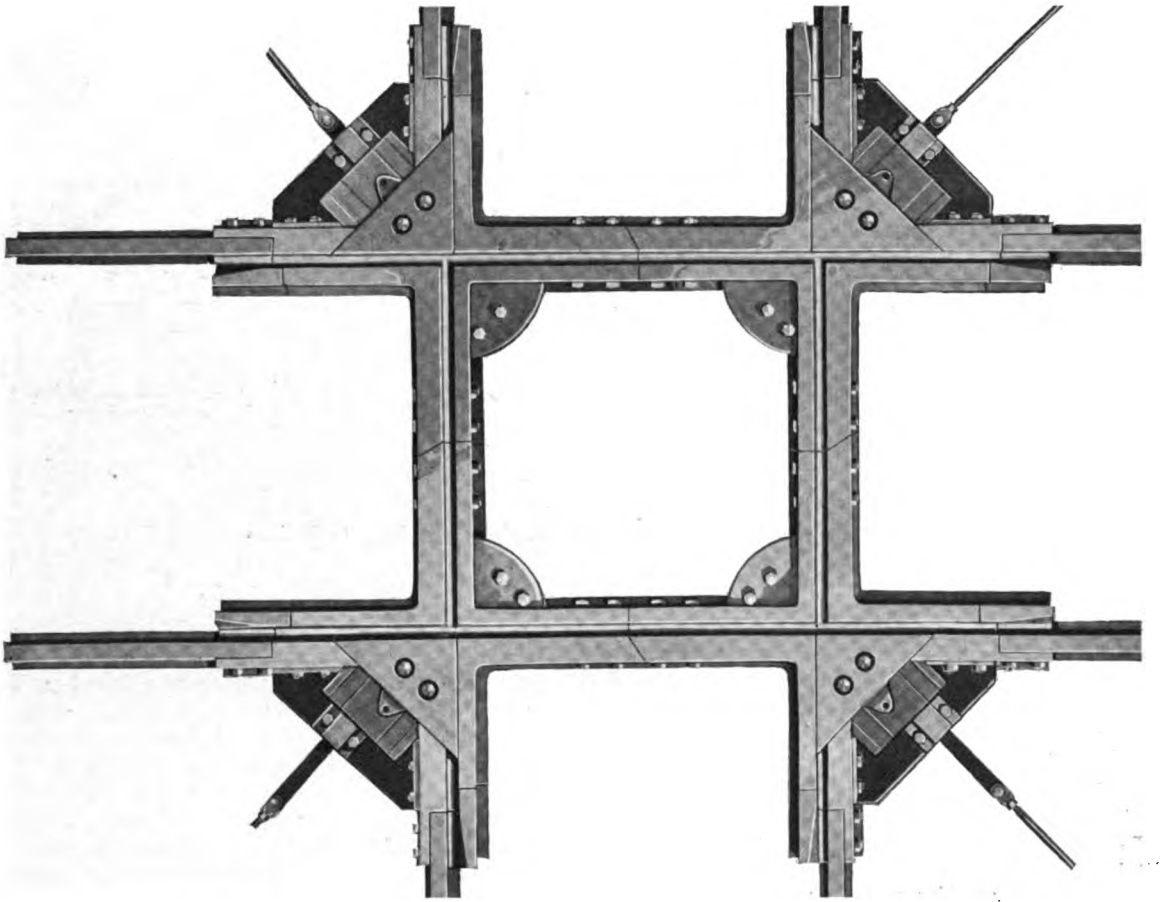
necessary in a turnout from a double gage track using three rails.

Crossing Frogs

A crossing frog is a rail crossing device designed to provide special intersecting flangeways at track crossings by means of which wheel flanges may pass freely over the main rail of either track.

Crossings on straight track are the simplest to construct and the easiest to maintain, this advantage increasing as the intersection approaches 90 deg. A disadvantage is that crossings at such angles ride hard because of the jar to the wheels crossing the open flangeways squarely.

When the angle at which the center lines of the tracks intersect, known as the central angle, is other than 90 deg., the crossing has two opposite acute



Eymon Continuous Rail Crossing
The Eymon Crossing Co.
(See Page 685)

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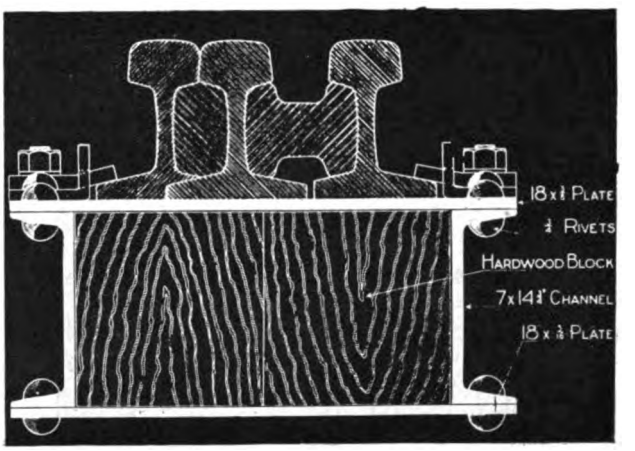
angle frogs, called end frogs and two opposite obtuse angle frogs called middle frogs. These frogs differ only in and by reason of their angles. As the wing rails converge to form the throat of an acute angle frog, they guard the wheel flange before it reaches the throat. If, however, the angle is obtuse, the wing rails of the frog do not guard the flange until it has passed the throat, so that an inside wing rail or guard rail is necessary. An obtuse angle frog so guarded is called a double-pointed frog. In case one or both tracks are curved through the crossing, the angles of opposite frogs are unequal. Crossings are made in one, two, or four sections, according to the angle of the intersection and convenience in manufacturing and handling.

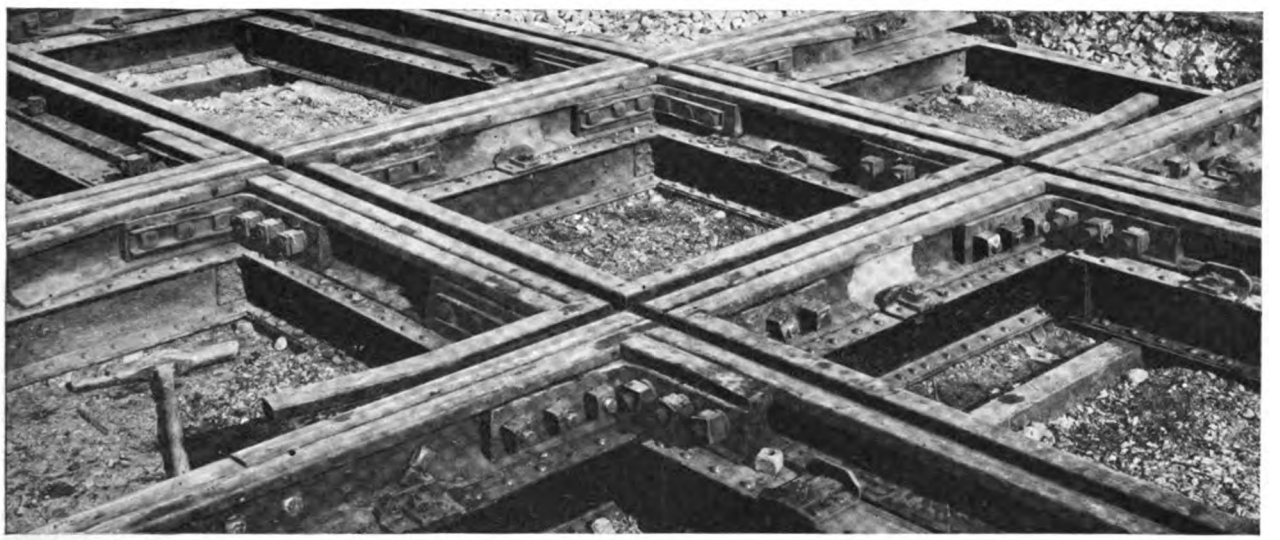
The four frogs of a crossing having a central angle of 15 deg. or less are so far apart that the middle and end frogs are commonly made of ordinary lengths and connecting rails of standard section are laid between. If the angle of the crossing is 8 deg. or less, movable point frogs are generally used in place of the middle frogs as a matter of safety and to conserve track space. A movable-point frog consists of two movable point rails, the free points of which face each other a few inches apart where they may be alternately operated against and away from a continuous knuckle rail kinked at the apex of the obtuse middle angle to serve as a running rail from one track to the other. Point and knuckle rails should be suitably fitted and reinforced. Movable point frogs are operated in pairs identical in movement and similar in arrangement to two sets of switch points facing each other.

Crossings of angles larger than 15 deg. are made usually of four frogs which are laid with abutting legs. Where the angle approaches 90 deg. crossings are sometimes made of one or two sections; usually when one track is of such relative importance that the rails extend through, with the rails for the secondary track butted against them. When the angle of crossing is not too acute the end frogs are double pointed and the inside wings or guard rails are joined, forming a double rail crossing. Easer rails are used to reinforce crossing frogs and to protect the points against worn wheel treads.

It is considered good practice in crossings of two tracks laid with rails of different weights to construct the crossings of the heavier section of rail, and to lay at least one rail of the same section as the crossing on each side thereof in the track of the lighter rail, thus placing the compromise joints where the jar of passing trains is not so severe as if the crossing frogs are joined directly to the light rails. It is not considered good practice to hot-bend the guard or wing rails for crossings or to cold-bend them more than about 20 deg., spliced joints being preferable for larger angles. The practices of breaking joints between adjacent running and reinforcing rails; of rigidly fastening frogs to heavy base plates; and of stiffening the crossing with reinforced angle straps are generally approved. Butt joints and miter joints are used for joining crossing



Section of a Wood Block Filled Steel Crossing Foundation
The International Steel Tie Co.



Track Crossing on Steel Girder Foundation
The International Steel Tie Co.

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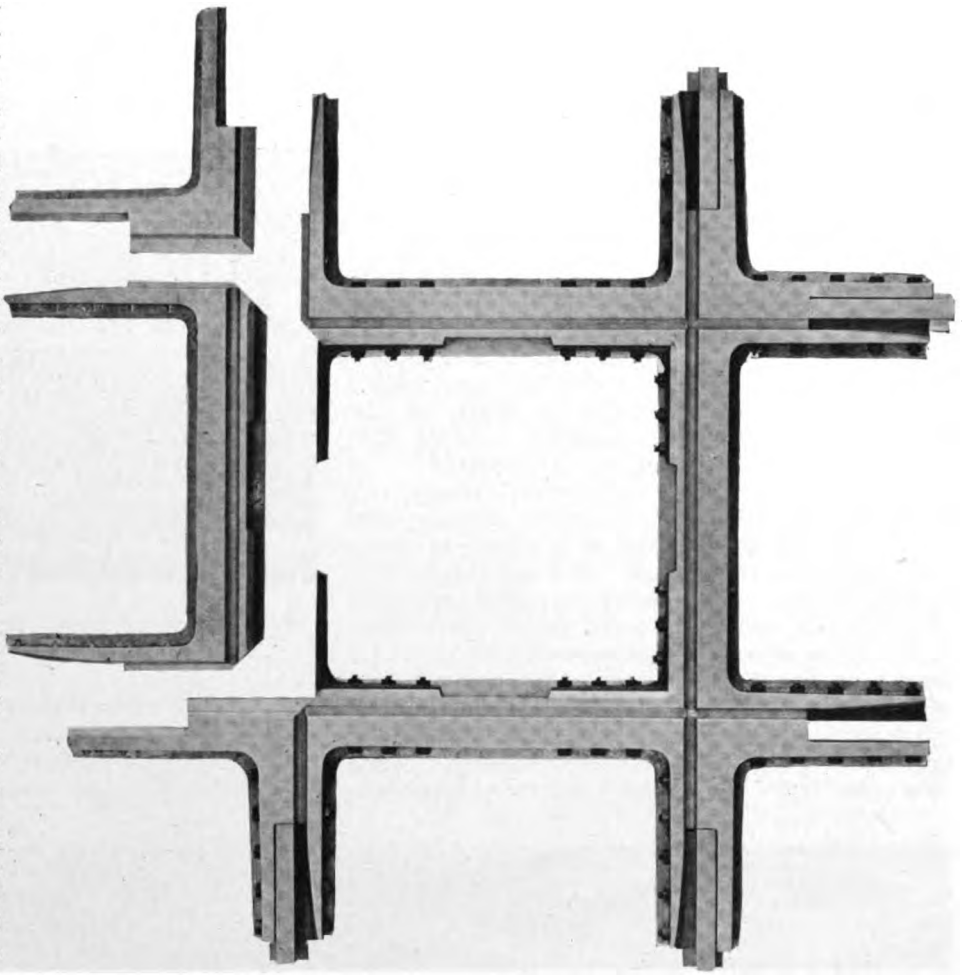
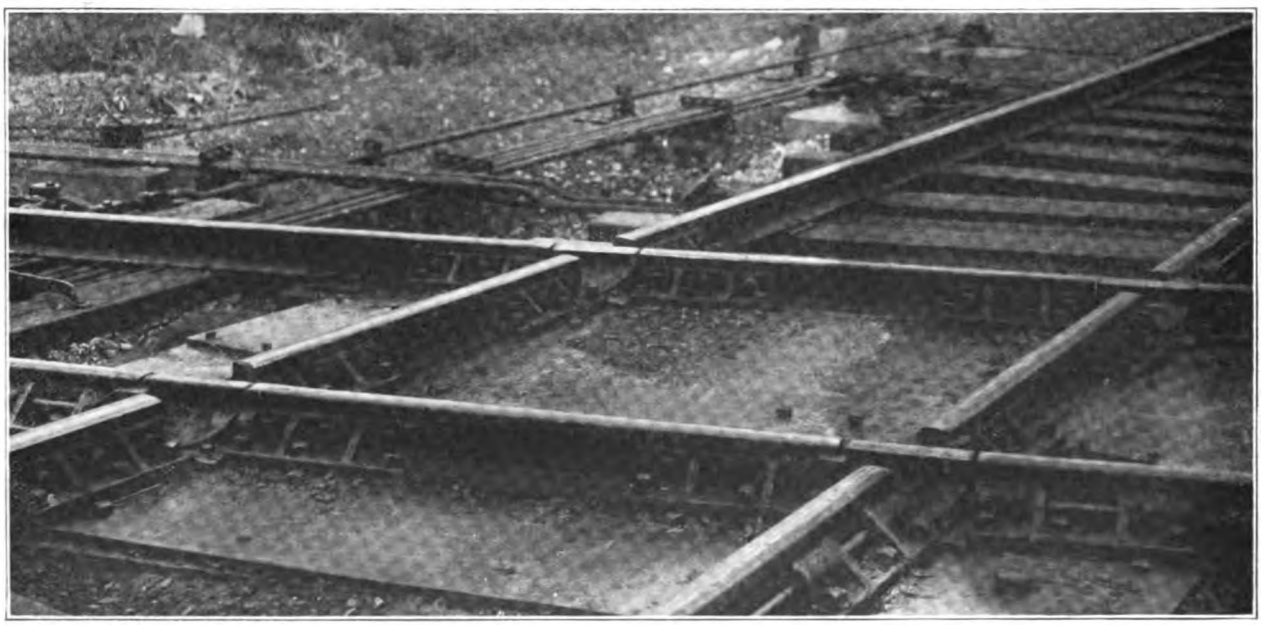
rails, the miter joint being most frequently used where the angle is acute. Crossing frogs are variously reinforced by means of outside angle blocks, by A-braces either fastened to or integral with the angle strap and by bolts extending through the frog point rails, filler blocks and wing rails. They are made of the same materials as turnout frogs, and are used with much the same effect.

Continuous rail effects are variously obtained by revolving devices or by sliding rails or castings. Any such track crossing device is usually made applicable to interlocking operation, the number of moving parts is minimized and it is preferably constructed of manganese steel.

The foundations of crossings and turnouts merit careful attention, as they bear double the stresses of single track foundations. Many crossings demand special treatment to preserve the surface and the alignment under the heavy traffic. Consideration should first be given



Balkwill Articulated Manganese Crossing
The Balkwill Manganese Crossing Co.
(See Page 654)



Continuous Rail Crossing
The Alexander Crossing Co.

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to perfecting the drainage, which preferably includes a line of 3 in. to 4 in. tile laid around and below the foundation with an adequate, clean, well-drained covering of ballast, preferably sharp crushed stone, graduated in size from 2 in. or 2½ in. at the bottom to ¾ in. or 1 in. at the top, of which a reserve supply should be available for renewals near the crossing site.

Reinforced concrete slabs from 15 in. to 20 in. thick are also sometimes used as crossing foundations. If traffic can be diverted they may be poured in place; otherwise, and more usually, pre-cast slabs are installed after which the crossing is replaced on an adequate cushion of ballast. Shallow, steel box-girder formations are also coming into use as permanent track crossing foundations. See Turnout. Also Track Crossing.

Under the caption of "Specifications for Frogs, Crossings and Switches," the A. R. E. A. has adopted the following specifications covering the materials and manufacture of frogs.

General Instructions

1. The company will furnish to the manufacturer specifications and drawings. The drawings will show rail sections, splice drilling, angles, alinement, general dimensions and such details as the company may desire.

2. When requested, manufacturers shall submit for approval detail drawings showing construction and dimensions of all parts to be furnished in accordance with these specifications. Conventional shading shall be used in sectional drawings. All dimensions and distances shall be shown plainly in figures. The title shall be placed in the lower right-hand corner.

3. The detail drawings shall be on sheets 22 in. wide, with a border line ½ in. from the top, bottom and right-hand edge, and 1½ in. from the left-hand edge. The standard length of sheets shall be 30 in. except that when necessary, longer sheets may be used and folded back to the standard length. Drawings of one subject only shall appear on a sheet. Scale of general drawings shall be 1½ in.=1 ft.; details not less than 3 in.= 1 ft.

4. The drawings of the company and the manufacturers' drawings approved by the company shall be a part of the specifications. Anything which is not shown on the drawings but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either but which is reasonably implied, shall be furnished the same as if specifically shown and mentioned in both. Should anything be omitted from the drawings or specifications that is necessary for a clear understanding of the work, or should any error appear in either the drawings or specifications affecting the work, it shall be the duty of the manufacturer to notify the company and he shall not proceed with the work until instructed to do so by the company.

Inspection

5. Material and workmanship shall be at all times subject to inspection by a duly authorized representative of the company, who will examine the material before it is worked in the shop. He will inspect the work during the progress and will also inspect the finished product, with power to reject materials and workmanship found to be unsatisfactory. He shall have free access to the shops and mills at any and all times during the progress of the work.

6. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery or during the progress of the work, and such defective material if furnished by the manufacturer shall be replaced by him at his own expense.

7. All facilities, labor and tools necessary for the shop inspection shall be furnished at the expense of the manufacturer.

8. When the manufacturer furnishes the rails, he shall supply the company with a certificate of inspection made by some competent person acceptable to the company.

Material

9. No. 1 rail, of the section ordered, as called for by the specifications, shall be used.

10. Fillers between the main and wing rails and between the main and easer rails shall be rolled steel. Throat filler blocks, not presenting a running surface, may be cast-iron.

11. Riser blocks shall be hard cast steel.

12. Metallic foot guards shall be either cast-iron, malleable iron or cast steel, except that strap foot guards shall be rolled steel. Wooden foot guards shall be of best quality hardwood.

13. Bolts shall be of double refined iron, mild steel, nickel or other alloy steel or heat-treated alloy steel. Bolt metal of iron or mild steel shall have a tensile strength of not less than 50,000 lb. per sq. in. and an elongation of not less than 15 per cent in 8 in. When nicked and then broken, the fracture shall be free from flaws and unwelded seams.

Bolt metal or nickel or other alloy steel or heat-treated alloy steel shall meet the respective requirements following:

For untreated nickel or other alloy steel:
Elastic limit, not less than 45,000 lb. per sq. in.
Elongation, not less than 20 per cent in 2 in.
Reduction of area, not less than 40 per cent.

For heat-treated or other alloy steel:
Elastic limit, not less than 75,000 lb. per sq. in.
Elongation, not less than 15 per cent in 2 in.
Reduction of area, not less than 40 per cent.

Elastic limit shall be not less than 50 per cent of the ultimate strength. The elastic limit, elongation, and reduction of area may be determined from a finished bolt or from a test piece ½ in. by 2 in. turned from a finished bolt.

14. Rivets shall be made of steel which may contain a maximum of 0.04 per cent basic phosphorus, 0.04 per cent acid phosphorus and 0.04 per cent sulphur. It shall have an ultimate tensile strength of 50,000 lbs. per sq. in. It shall bend flat upon itself without fracture and when nicked and bent around a bar of the same diameter as the rivet rod it shall give a gradual break with a fine silky uniform fracture.

15. Reinforcing bars shall be of wrought-iron or mild steel.

16. Plates shall be of rolled steel.

17. Springs shall be of the best quality spring steel and of the dimensions and capacity shown on the plans. They shall meet the following tests:

(a) Each spring shall be placed on the testing machine and forced down solid four times.

(b) After the foregoing, each spring shall be placed on end on a flat plate, and the distance between the plate and the other end of the spring measured by means of the standard depth gage, this measurement being the free length of the spring, which must conform to the plans within ⅛-in.

(c) Double springs shall be assembled and a load at least 25 per cent greater than the rated capacity of the spring shall be applied for 30 seconds. Upon release neither spring must vary from its original free length. If either one does so vary, it shall be rejected.

(d) The inner and outer coils of springs shall be coiled in opposite directions.

18. Spring covers shall be made of malleable iron.

19. Braces shall be made of malleable iron or forged steel.

20. Stops and hold-downs shall be made of mild steel.

21. The anti-creeping device shall be made of mild steel.

22. Switch lugs shall be mild steel.

23. Switch rods shall be mild steel.

Workmanship

24. Workmanship shall be first-class. Bends shall be made accurately in arcs of circles and without injury to the material. Welding will not be permitted in any part of the frogs or in the switch rails. Planing shall be such that abutting surfaces will fit accurately together. Ends of rails shall be cut at right angles to

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the axis of the rail except where otherwise specified. Burrs shall be removed.

25. No paint, tar or other covering shall be used before inspection.

26. The alinement and surface of all finished work shall be even and true, and shall conform to the angles specified.

27. Rolled fillers shall fit the fishing angles and the web of rail for a distance of ½ in. above and below the base and head, respectively, and shall maintain the required flangeway. Throat filler blocks shall fit the rail sufficiently well to maintain the required spacing. Where the brand of the rail interferes with the fit of the filler the brand shall be chipped off. Fillers shall be grooved or cut out to fit over rivet heads.

28. Heel riser blocks shall fit the head, base and web of rail as provided under rolled fillers.

29. Solid foot guards shall fit the rail sufficiently well to maintain the required spacing. Strap guards shall have a minimum thickness of ⅜-in. of the width shown on plan and shall be fastened to the web of the rail by bolts or rivets not less than ¾-in. in diameter.

30. Bolts must be round and true to size, with square heads and nuts. Threads must be accurately cut and nuts must have a wrench-tight fit. Each bolt must be provided with an approved head lock and a nutlock of approved pattern large enough to give full bearing for the nut. A ¼-in. cotter pin shall, when required, be placed outside of and close up to the nut after it is tightened. Beveled washers must be used wherever necessary to give the head and nut a full, square bearing. Separate head lock shall be of material not less than $\frac{3}{16}$-in. thick. Washers used under heads may be of such design as to act as head locks. Bolts must be long enough to allow the nuts to be brought out from under the head of the rail, with a suitable washer not less than ½-in. thick, so that the nuts may be readily tightened with an ordinary wrench.

31. The diameter of the rivets shall be of full size shown on plan, and the diameters of the rivet holes shall not be more than $\frac{1}{16}$-in. greater than the diameters of the corresponding rivets. The rivets shall be of sufficient length to provide full, neatly made heads when driven. They shall be driven tight, bringing all adjacent parts into contact.

32. Rivets, when not countersunk or flattened, shall have standard button heads of uniform size for the same size rivets. The heads shall be full and neatly made and concentric with the holes. When the rivet heads are countersunk they shall be flush with the plate and must fill the holes.

33. Reinforcing bars shall fit the fishing angles and the web of the rail throughout their length.

34. Plates shall be flat and true as to surface.

35. Springs shall have the ends square with the axis, so that when the spring is placed on end on a flat surface it will stand perpendicular thereto.

36. Spring covers shall be of such dimensions as to permit a proper working of the springs and shall be provided with a spring bearing for each end of the spring.

37. Braces shall fit the head and the web of the rail accurately.

38. Stops shall be so placed on plates as to hold the spring rail at 1⅞-in. opening at the ½-in. point. Hold-downs shall fit the stops so as to allow at least 2-in. horizontal play and not more than ⅛-in. vertical play.

39. The anti-creeping device shall fit accurately to the parts of the frog or joint bars.

40. Holes for main bolts shall be drilled from the solid. No punching will be permitted except in bottom plates and washers. Drilling shall be accurately done, on bevel where necessary, and holes shall be made $\frac{1}{16}$-in. less in diameter than the bolt to be used. Then the parts shall be assembled and the holes reamed so they are straight and true, with no offsets between the adjacent parts, and of such size as to give the bolts a driving fit for their entire length.

41. In lieu of the above specification for drilling and reaming, the manufacturer may assemble and accurately fit all the parts, before any drilling whatever is done; after the parts are securely clamped in their correct positions the holes may be drilled of such a size as to give the bolts a driving fit for their entire length.

42. The number of the frog, the maker's name, the weight of the rail and the date shall be plainly stamped with ¾-in. figures and letters on the flare of one wing rail for rigid frogs and on the flares of both wing rails for spring frogs, or a plate shall be fastened to the frog with the same information (See Page 660 and 742).

FROG, BOLTED PLATE. A bolted frog fastened to a base plate by rivets or clamps. See Frog, Bolted, Riveted.

FROG, BOLTED, RIVETED. A rigid frog made of rails bolted together and riveted to a base plate.

FROG, BUILT UP. A frog in which the parts are assembled and held in place by bolts, rivets or clamps as differentiated from a frog cast in one piece. See Frog.

FROG, CARBON RAIL. A rail frog made with rails of carbon steel. From its inception the railway frog has and is still commonly made of carbon steel rails. A large percentage of all the frogs manufactured are today made of this material. See Frog.

FROG, CAST MANGANESE STEEL. A frog made of a solid manganese casting. See Frog, Solid Manganese.

FROG, CENTER. See Frog, Crotch.

FROG, CLAMPED. A type of built-up frog in which the parts are held together by clamps. See Frog.

FROG CLIP. A small metal plate sometimes used to fasten the rails of a frog to the base plate.

FROG, CONTINUOUS RAIL. A design of frog in which an unbroken parent track rail is maintained through a turnout by the use of a raised rail which carries the wheel flange over the parent rail head and down again on the opposite side. As the vertical curve of this rail is of comparatively short radius, this type of frog is most used where the traffic movements are slow.

Another type of continuous rail frog consists of a short length of rail so mounted on a pivot that it can be swung and secured in line with the rail of either track by means of locking bolts, levers and the usual switch stand or interlocking arrangement. See Frog.

FROG, CROSSING. A frog which provides special intersecting flangeways at the intersection of the rails of two tracks which cross each other at grade, by means of which wheel flanges on either track may pass freely across the rails of the opposing track. Four crossing frogs are used for a single track crossing, one at each of the four rail intersections. See Frog. Also Track Crossing.

FROG, CROTCH. A frog at the intersection of the lead rails of the two outside switch leads in a three-way turnout. This term is also commonly applied to a frog used in any turnout from a curved track in which the radii of the main track and the turnout track are approximately equal.

FROG, CURVED. A special frog having one or both sides curved.

FROG, DOUBLE POINTED. A frog having two points which face each other. In the case of a special turnout when a double pointed frog is

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used one point is a false point, formed by the intersection of the guard rails. Such a frog is necessary in turnouts from tracks of double gage using three rails.

FROG, DOUBLE SPRING RAIL. A frog of which each wing is held in position by a spring. Double spring rail frogs are in use in yards where movements are slow and traffic heavy and where extra precautions are considered necessary to avoid chance of derailments, as at passenger terminals and approaches to railway ferry boat transfer tables. See Frog.

FROG, FLANGED. A frog of the cast manganese or the built-up rail type made with raised flanges on the outsides of the wing rails. These wing flanges are placed ahead of the frog point and converge to the flangeway just back of the point so as to guide wheel flanges in their proper course past the open flangeway of the throat of the frog and eliminate the necessity for guard rails. See Frog.

FROG, HARD CENTER. See Frog Manganese, Rail Bound.

FROG, MANGANESE INSERT. A rail frog which is provided, within the limits of the surfaces which are subjected to the most severe wear, with manganese castings or inserts. This term has been applied incorrectly to frogs which have entire centers of cast manganese, which are properly termed manganese body frogs or rail-bound manganese frogs, according to the extent of the center casting.

The term manganese insert implies more than one small manganese piece inserted in a rail frog to provide hard surfaces where wheel wear is most severe, especially at the throat and tongue of the frog. See Frog. (See Page 742).

FROG, MANGANESE, RAIL BOUND. A frog with a manganese steel center casting bolted or keyed to surrounding rails of carbon steel. The so-called hard center varies in size but is designed to cover the area of most severe wear. See Frog.

FROG MIDDLE. See Frog. Also Frog, Crotch.

FROG, MOUTH OF. The space between the wing rails, converging from the toe and terminating at the throat of the frog.

FROG, MOVABLE POINT. A frog consisting of two switch point rails or pointed rails that are movable and placed facing each other and a few inches apart. The points fit against a reinforced knuckle rail, and are so arranged that when one point is closed the other is open. Both sets are usually operated from one switch stand. In this way both rails are continuous through the frog. Movable point frogs are used principally in small angle crossings and slip switches in yards. They are peculiarly adapted to use where both tracks are curved and where continuous unbroken rail is desirable on both tracks. See Switch, Slip.

FROG NUMBER. The classification of a frog, determined by dividing the length of the frog by the spread. For example: a frog which has a spread of one foot, at a distance of ten feet from the point, is termed a No. 10 frog. To find the frog number, find the place where the gage lines of the frog rails are one foot apart. The number of the frog is the distance in feet from this place to the point. Although sufficiently accurate for practical purposes, this method is approximate, as measurement should really be made from the theoretical point of frog. Even the actual point of a frog which has been long in service is usually indeterminate on account of wear. Theoretically, the frog number is one-half the cotangent of one-half the frog angle, or the number of units of length in which the spread is one unit. The frog specifications of the A. R. E. A. stipulate that the manufacturer shall stamp the number of the frog on the flare of the wing rail, or on a plate fastened to the frog. See Frog.

FROG POINT. That part of a frog lying between the gage lines extending from the theoretical point to the heel. The angle of a frog is generally measured along the point.

FROG, RAIL. A frog built of rails with the necessary fillers and fastenings, as distinguished from cast manganese frogs. See Frog.

FROG, RIGID. A frog without movable parts, as distinguished from a spring rail or movable wing frog. A rigid frog provides two fixed open flangeways. Therefore it is used commonly in turnouts involving main tracks of approximately equal importance and in other than main tracks. Having no movable parts, the rigid frog is comparatively simple and inexpensive to manufacture. It is a sturdy, long-lived type, easy to maintain. Owing to its fixed open flangeways it is not a smooth riding frog and it will wear unequally with an excess of traffic on one track. See Frog.

FROG, RIGID, BOLTED. A rigid frog in which all members are fastened firmly together by means of bolts to prevent any movement among the parts. A simple light design of bolted rigid frog is made of two point rails, two wing rails, two point filler blocks, with two bolts, nut locks and nuts, placed ahead of the flare of the wing rails and bolted through the webs of the rails. A similar frog has the entire space from wing flare to theoretical point of frog filled and fastened with seven or more bolts. See Frog.

FROG, RIGID, BOLTED, RIVETED. A frog in which the parts are bolted together and riveted on a steel plate known as a base plate, which adds strength and stiffness to the device. See Frog.

FROG, RIGID, CLAMPED. A type of frog held together by means of heavy clamps, one of which passes under the rails a few inches back of the point and another just ahead of the flare of the wing rails. The clamps turn up at the ends and hold the frog members in place by means of steel keys. See Frog.

FROG, RIGID, RIVETED. A simple rigid frog in which the rails and wing rails are riveted independently to a base plate and the rails which form the points are also riveted to each other, without bolts to bind the parts horizontally. See Frog.

FROG, ROLLED MANGANESE. A frog built of rolled manganese rails. Advantages that this frog has over a manganese cast frog are that the increased strength and resistance to wear of the man-

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ganese are retained, while a longer life of the frog is obtained because broken or worn parts of the built-up frog can be replaced at relatively small trouble and expense. See Frog.

FROG, SINGLE. A frog having only one point.

FROG, SOLID MANGANESE. A manganese frog cast to conform strictly to the outlines of a rail frog only in so far as the purposes for which it is used demand. The working contours being those of a rail frog, the casting may be of any desired thickness. See Frog. (See Page 742).

FROG, SPECIAL. A frog of unusual angle or construction, which is only manufactured according to individual specifications. See Frog.

FROG, SPRING WING RAIL. A frog, one wing of which is movable and is normally held against the point by means of a heavy spring, preserving the practical continuity of the main track rail at the frog and thus avoiding the shock incident to crossing the open flangeway of a rigid frog. It is designed for use in turnouts from tracks on which fixed open flangeways are undesirable and is most commonly placed in high speed main tracks for turnouts to tracks of secondary importance.

In addition to the fillers, easer rails, foot guards and base plates of the rigid frog, the movable wing of the spring rail frog is ordinarily equipped with springs, stop blocks, anti-creepers, and a hold-down device. The spiral springs are either enclosed in malleable iron casings at each end of a bolt which extends through both rails ahead of the throat of the frog, or they are placed side by side in a double-barreled casing, which is riveted to the base plate on the spring rail side between the frog point and the flare of the wing rail.

Spring rail frogs are right hand or left hand, according to the direction of the turnout as viewed from the switch point, looking toward the frog. See Frog.

FROG, TURNOUT. A frog designed to provide special intersecting flangeways by means of which wheel flanges may freely pass over the main track or make use of the turnout. See Frog.

G

GAGE (of Track). The shortest clear distance between the heads of the running rails.

The standard gage of track in the United States, Canada, England and most European countries is 4 ft. 8½ in. (1.4351 meters), measured ⅝ in. below the top of the rail. The United States has also several thousand miles of narrow gage track (mostly 3 ft.). The 5 ft. 6 in. (1.676 meters) gage is standard in Spain and common in the East Indies and Chile. About 60 per cent of the track in the Argentine Republic is 5 ft. 6 in. gage, 30 per cent is meter gage and the remainder, 4 ft. 8½ in. gage. In Russia the standard gage is 5 ft. (1.534 meters), with some exceptions of 4 ft. 8½ in. gage. In Norway, South Australia, Japan and Java a gage of 3 ft. 6 in. (1.0668 meters) is generally used, which gage is also standard in South Africa. Narrower gages are used in various countries, usually for temporary or development lines, widths of 3 ft. 3⅜ in. (1 meter) being common in Algiers, Brazil, Corsica, Greece and Switzerland. Africa and Germany have some lines of 2 ft. (0.6 meter) gage. Many lines of wider and narrower gages in this and other countries have been altered to 4 ft. 8½ in., which is now the gage of a large proportion of the world's steam railways.

The recommendation of the A. R. E. A. is that on curves sharper than 8 deg. the standard gage of 4 ft. 8½ in. should be widened ⅛ in. for each 2 deg. or fraction thereof to a maximum of 4 ft. 9¼ in., but that the gage, including widening due to wear, should never exceed 4 ft. 9½ in. When frogs are placed on the inside of curves, the gage should

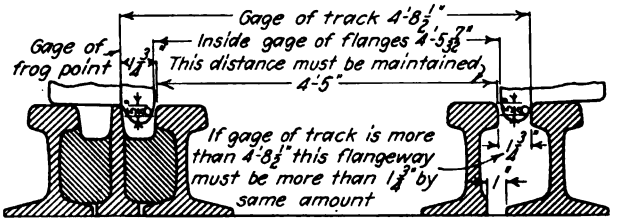

Diagram of Standard Gage of Track

be 4 ft. 8½ in. and the guard rail flangeway should be widened to compensate for any increase in gage.

The special conditions encountered and the methods of maintaining the gage of track on curves, including the widening of the gage, arise from the action of the wheels fastened rigidly to the two ends of an axle and to the fixing of two or more axles at right angles to the center line of a frame as of a car truck or a locomotive. When two wheels of equal diameter are fastened solidly to the opposite ends of an axle, they rotate together and tend to move equal distances in a straight line. The flanges of car and engine wheels are designed to prevent the wheels from leaving the rails. On curves the leading outside wheel flange of a track is pressed against the inside of the head of the rail, while the flange of the inside rear wheel rolls correspondingly away from the rail head. When this pressure against the outside rail is sufficient, the wheels slip sidewise on the rails, the truck turning about its inside rear corner to the nearest possible approach to radial movement of its fixed axles around the curve. The tendency of the truck to run straight keeps the flanges of the outside wheels pressing the rail head so hard that they travel on the fillets or curved side of the wheel flanges until they suddenly slip back onto the treads with a wedging pressure of the flanges, which tends to spread the rails and to cant the inside rail as the inside wheels are forced squarely across the rail. This wedging and slipping action on curves is relieved in some measure by widening the gage slightly on sharp curves, by coning the wheels and by elevating the outside rail. It is plain, however, that the parallel axles of a truck cannot be radial to the curve, that the nearest approach is that position in which a line half way between the axles is radial, and that the conditions demand special devices and special maintenance as distinguished from straight track.

The canting of the inside rail results in its outer flange being pressed into the wood of the tie until it cuts an inclined bearing unless the tie is well protected. Tie plates help to prevent canting and to maintain gage, especially if the plates have ample

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bearing surfaces, more than two available spike holes and outside shoulders. Sufficient well drained ballast, properly tamped also assists greatly in the maintenance of curves. The widening of gage is important to prevent rail wear on curves, for if the gage is too tight the locomotives which have the longest wheel bases will force the rails apart or wear the gage wide at the expense of the rails. Obviously, then, the width of the gage on curves should be considered in connection with the wheel bases of locomotives in use, giving due consideration to the existence of flangeless middle drivers if this type is employed, and to the type of lead truck, which may be rigid or swivel hung.

GAGE PLATE (Switch). A metal plate designed to hold the running rails of a track to gage at that point of a switch. The gage plate is about ½ in. thick by 6 in. wide by 6 ft. long, and is spiked on the tie, each end extending beneath and supporting the base of a rail, which is likewise fastened to the tie by means of track spikes extending through holes in the gage plate, the extreme ends of which are commonly upturned to act as steps for the heels of rail braces. The gage plate is insulated when required by a central division on the center line of track, in which insulating fibre is inserted between the two bolted parts of the plate. See Switch. Also Gage (of Track).

Gage Plate with Risers and Braces

GAGE PLATE, CENTER POINT (Slip Switch). A gage plate about 8 ft. 6 in. long designed to extend from outside to outside of the crossing rails on the tie which bears the center points of a slip switch to help to hold the rails in their correct relative positions and to provide a bearing surface for the center points. The gage plate is supplied with rail brace stops for the stock rails and with slide plates for the switch points, as well as with spike holes through which it is fastened to the tie.

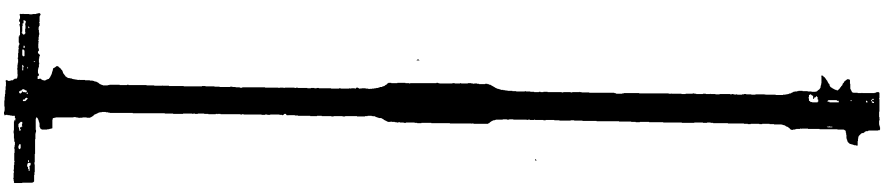
GAGE PLATE, END POINT (Switch Slip). A gage plate about 10 ft. long designed to extend from outside to outside of the crossing rails on the tie which bears the end points of a slip switch to help to hold the rails in their correct relative positions and to provide a bearing surface for the end points. The gage plate is supplied with rail brace stops for stock rails and with slide plates for the switch points, as well as with spike holes through which it is fastened to the tie.

GAGE PLATE, INSULATED. See Gage Plate (Switch).

GAGE LINE (of Rail). A line ⅝ in. below the crown on the gage side of the rail at which measurements of gages are made.

GAGE (Track Tool). A bar of steel, or of wood and steel, supplied to track gangs for testing the width (or gage) of track between the heads of the rails.

The track gage is usually about 5 ft. long, so that the ends of the bar extend across the tops of both running rails of the track when the gage is applied, while the depending lugs indicate the correct gage between opposite rails. The bar usually terminates in a single lug casting at one end and in a forked lug casting at the opposite end, although some gages are forked at both ends. The complete gage has lugs on the bottom for use on running rails and other lugs on the top to measure the spacing from a frog to the gage side of its opposite guard rail. One guard rail lug is usually carried on a short center projection at the forked end. The gaging surfaces of guard rail lugs face in the same direction because the head of the guard rail lies between its gage side and the gage side of the frog. When applied, one guard rail lug is hooked over the guard rail head while the knob of the casting on the opposite end of the bar should just touch the tongue of the frog ⅝ in. below the running surface. The primary object of the forked casting is to provide two gaging points several inches apart in a plane at right angles to the axis, so that when these opposite gaging points are in contact with the gage line of the head of the rail, the tool will lie at right angles to straight track or radial to curved track. The gaging faces of the tool are commonly set 1¼ in. back of the ends of the bar. They are vertical to the axis of the gage and about 1¼ in. deep.



Combination Track Gage and Level
The Kalamazoo Railway Supply Co.
(See Page 729)

As the gage of track is measured ⅝ in. below the top of the rail, the contact of the gage lugs and the head of the rail should be at that depth. With a vertical, plane-surface lug 1¼ in. deep, the precise gage of track cannot be indicated unless the side of the rail head is vertical to the rail base. In many sections of rail the head is a little wider at the bottom than at the gage line, so that track gaged with such a tool would be wide. A lug casting which is adapted to exact gaging has a knob-like projection,

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the salient point of which is 5/8 in. below the top of the rail when the gage is applied.

Solid steel gages are preferred for construction work and other rough gaging. It is necessary to insulate gages on track carrying electric current, where it is usual to use a gage made of a wooden bar with steel gage castings, or sometimes an insulated all-steel gage. Some gages are provided with adjustments to accurately gage the widened track of sharp curves.

GAGING (of Track). The act of testing and maintaining the space between the two lines of rails of track in uniformly correct relative positions as regards the shortest clear distance between their gage lines.

Track is laid and maintained to a certain line relative to the center line. Ties are first laid to a line stretched at a distance of half the tie length at one side of stakes denoting the center line of the proposed track. The line side of ties of east and west tracks is usually the north side and of north and south tracks, the east side. The gage line of track is on the line side of the ties, and the width of the track is gaged therefrom. When ties are laid to line they are marked equi-distant from the line ends, and the gage line rails are laid and spiked to this line. By use of the track gage the second line of rails is placed at the proper distance from the first line. A rail should not be held or sprung into place with a gage or drawn into line with a spike driven diagonally, but it should always be moved to its correct position with track bars and held there by two or more men while being spiked to the tie with spikes driven vertically. The best practice of maintaining track gage is not to gage it one or twice a year, but to keep the gage at all times reasonably correct and uniform. The continuous method is safer and more economical than the periodical program of "gaging through." Track that is uniformly of slightly wide gage (say 1/4 to 3/8 in. over standard width) need not be regaged, but track that is uneven as to gage should usually be the first to receive attention. Track of tight gage should be remedied at once. Gage frequently widens on account of the slight tilting out of the rails. The science of keeping track to good working gage depends on frequent testing with the track gage, keeping records of the results and correcting the inequalities as they develop. While these inequalities can usually be detected by eye and felt by side lurching of the cars, it is the trackman's duty to test the track frequently with a track gage, to know the exact condition and causes and to apply the remedies promptly.

GASKET (Switch Lamp). A packing ring or washer. Gaskets are used around the circumferences of lenses to protect the edges and to prevent the passage of air.

GATE (Fence). A suspended movable barrier, usually a hinged open framework of wood or metal, used to close a passageway through a fence.

Right-of-way fences are supplied with gates at private grade crossings of roads used to gain access to property abutting on the railway lands. These gates, which formerly were made of wood, are now made also of iron, usually an iron frame covered with wire netting or fencing, or sometimes an iron bar from which a network of chains depends. The minimum length of right-of-way gates is 12 ft., a standard gateway of 16 ft. being established in some districts to accommodate farm machinery. A gate is commonly reinforced against sagging by some form of bracing device and is made of a height to correspond with that of the fence.

Gates are hung to swing well clear of the ground and to open away from the track, preferably in such a manner that they will close and latch by gravity, for there is an element of danger involved in an open gateway which permits stock to wander on to the railway tracks. The duty of keeping gates closed devolves equally on the occupants of the properties concerned and the landed proprietor as well as the section foreman, who is responsible for policing the railway company's property.

GIRDER STAND (Switch, Slip). A parallel throw, jack-knife switch-point throwing device placed near the center points of a slip switch whence the end and center switch points may be operated by means of reach rods, bell cranks and connecting rods. The levers are pivoted between two long ties on a flat steel frame, usually extending over four ties. The two levers of a double slip switch are parallel in movement, each lever operating in a vertical plane through 180 deg. parallel with the adjacent rail, its movement governing the positions of one set of end switch points and one set of center switch points. The design of girder stand depends on whether the slip switch to which it will be applied has movable points or rigid frogs and whether it is a double or a single slip switch. Various designs of parallel ground throw and four-way low yard stands are made to serve this purpose. See Switch, Slip.

GUARD POINT. See False Point.

GUARD RAIL. A rail laid parallel to the running rails of a track, usually between them and close to one rail, with only a narrow channel between, which arrangement tends to prevent wheels from being derailed, to keep derailed wheels on the ties, or to prevent the flanges of wheels from striking the points of frogs in the opposite line of rails.

Guard rails are used opposite the throats of turnout frogs and on sharp curves, on bridges, etc., where precautions against derailments and their results are necessary. They are preferably of the same section as the running rails and are curved near the ends so as to flare toward the center of the track for the purpose of guiding wheels gradually through the flangeway provided. They may be as high but should never be higher than the running rail.

TURNOUT GUARD RAIL

A flangeway rail placed opposite the frog of a turnout, parallel with and fastened to the running rail as well as to the ties, for the purpose of providing a groove between the adjacent rail heads to so guide a wheel as to keep its mate on the other end of the axle from fouling the otherwise unprotected point of the frog.

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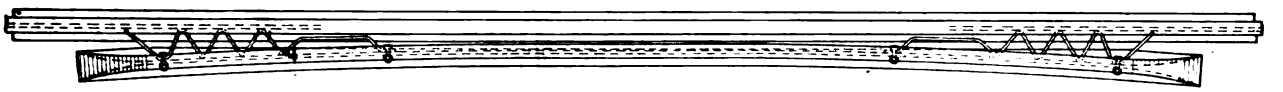
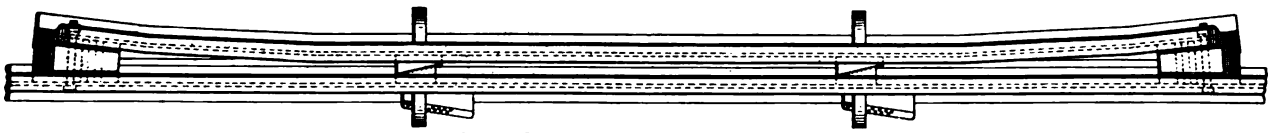
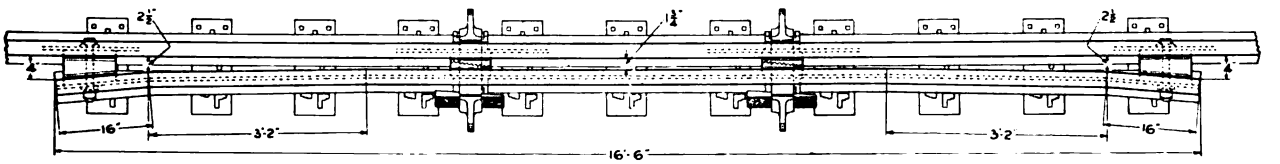


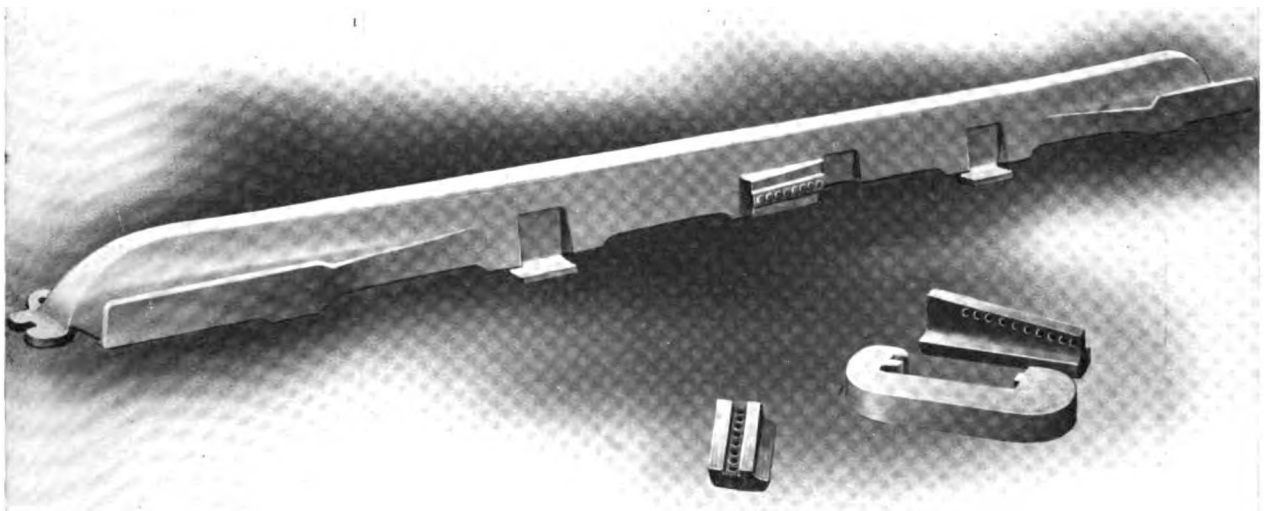
Guard Rail with Depressed Ends and Metal Foot Guards



Clamp Guard Rail with Beveled Ends



Clamp Guard Rail with Straight Ends



Solid Manganese Steel Guard Rail
Wm. Wharton Jr. & Co., Inc.

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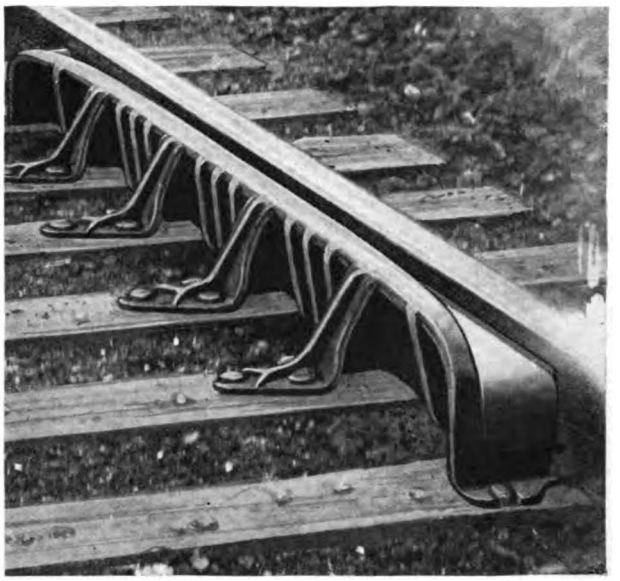
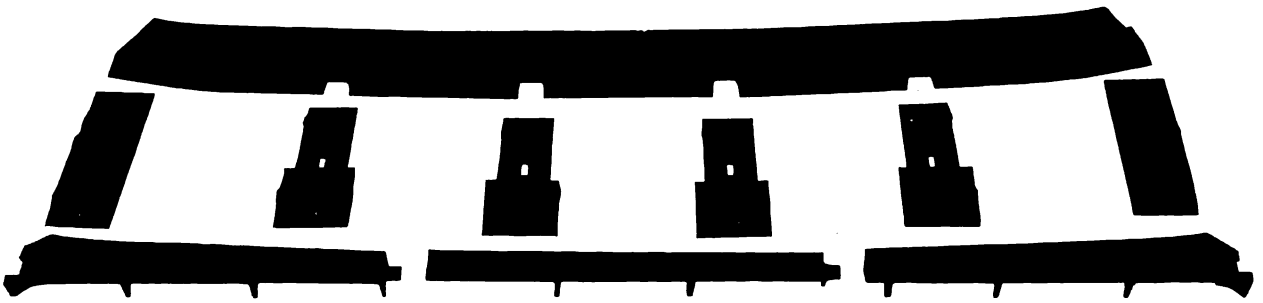
While many lengths are in use, the guard rails recommended by the A. R. E. A. are 11 ft. long for No. 8 turnouts and 16 ft. 6 in. long for No. 11 and No. 16 turnouts. These lengths cut without waste from 33-ft. rails. They are made of the same section as the running rails to which they are variously fastened by means of plates, bolts, braces, clamps, etc., with metal separators between to preserve the flangeway width, while holding the guard rail rigidly in place.

The guard rail is set and maintained so that its gage line, ⅝ in. below the crown on the side adjacent to the running rail, is 4 ft. 6¾ in. from the gage line of the frog. The flangeway width, between the gage lines of the guard rail and the running rail of straight standard gage track should, therefore, be 1¾ in. If the gage is widened, as on a curve, the distance from the gage line of the guard rail to the gage line of the frog is correspondingly increased. In case the flangeway is widened ¼ in. or more by wear or use, the adjustment is made with reference first to the distance of the guard rail from the frog.

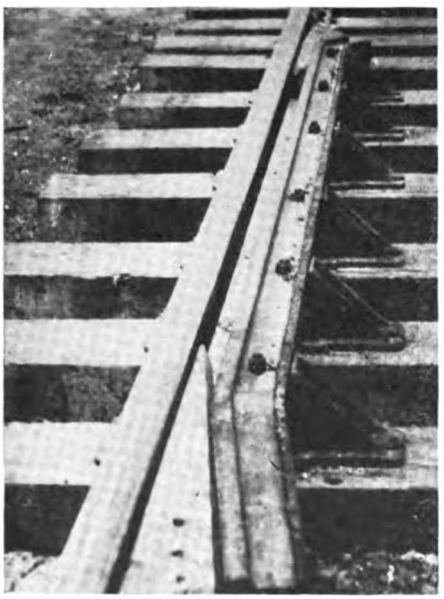
The ordinary track turnout includes two symmetrical and interchangeable guard rails, one placed parallel and adjacent to the opposite running rail of each track, with its center about opposite the point of the frog, so that the flanges of wheels approaching the frog on either diverging track will be held clear of the point while passing the open space at the throat. Those furnished for use with spring rail frogs must provide flangeways at least long enough to cover the movable wing rail.



Ajax Manganese Steel One-Piece Guard Rail
The Ajax Forge Co.
(See Page 629)



Newhall Guard Rail with Tie Plates and Foot Guards
The Cleveland Railway Supply Co.



Positive Girder Guard Rail, Fallon Type
The Positive Rail Anchor Company

The turnout guard rail is made straight throughout the middle one-fifth to one-third of its length between the flares, except in isolated cases where the frog and running rail are curved. The flare is usually made in two bends, the first being a divergence of only 1½ in. to 2 in. in as many feet and the second bringing the end of the guard rail 5 in. or more from the running rail, where it is preferably beveled or depressed to avoid catching objects dragging from passing trains.

Early styles of guard rails were fastened only to the ties. As the side thrusts from wheel flanges tend to cant the head of the guard rails inward, they were later furnished with metal separators fitting between the webs of the guard and running rails and fastened to both by means of threaded bolts. Usually one or two separators maintain the

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flangeway width while an end block holds the guard rail at each end in the same manner.

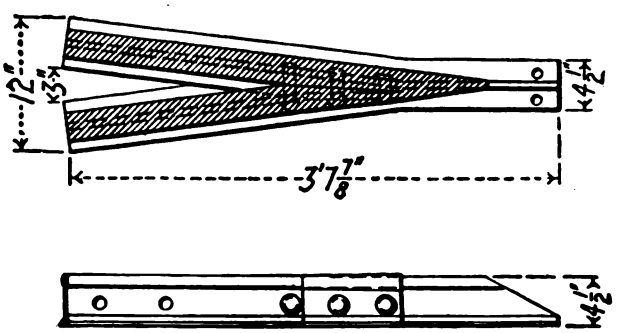
A more recent development is the guard rail clamp. One or more forged clamps extend underneath both the guard and running rails, the ends of the clamps curving up and in toward the webs of the rails. Between the rails and in line with the clamps is fastened a two-piece metal separator made of opposing wedge members, the contact faces of which are provided with identical corrugations to prevent slipping. A third and larger wedge member, driven between the clamp and the outside of the rail, keys the clamp, the running rail, the guard rail, and the separator rigidly in place. A cotter holds the clamp wedge in position. Broad metal blocks formed to serve also as foot guards, are fitted between the flaring ends of the guard rail and the running rail, and also help to hold the former in place by means of special bolts which pass through both rails and the block.

Guard rails are also made of manganese steel cast in various designs and in one or more parts, including some of the fastenings. Such designs frequently include the rail and the braces in one casting and sometimes also the clamps, halves of the separators, the end blocks and the plates, all as parts of one guard rail casting.

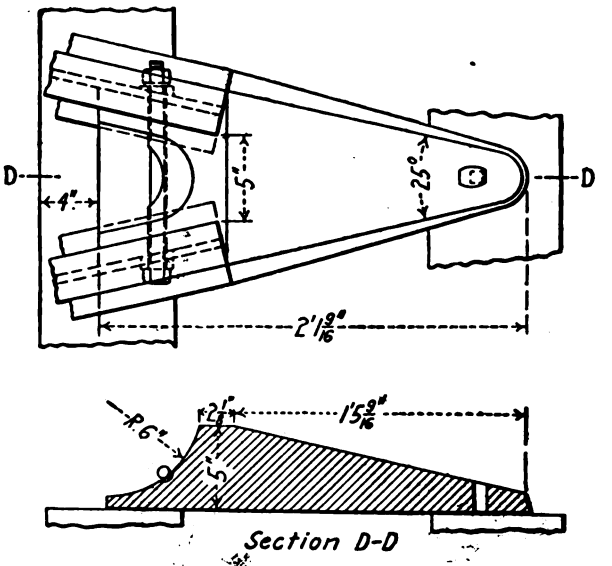
Bridge Guard Rail

A line of rails laid parallel to and between the running rails of a track over a bridge and its approaches to keep derailed wheels close to the running rails.

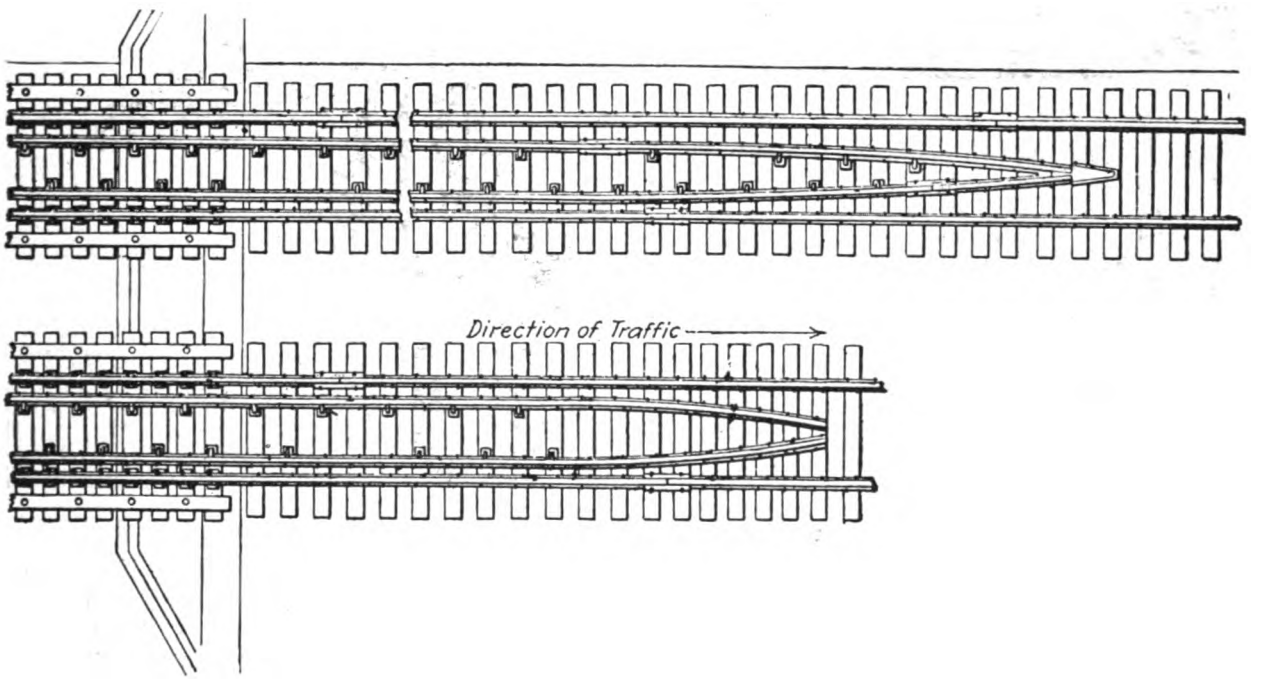
It is considered good practice to lay such a line of rails 8 to 9 in. inward from each running rail to keep wheels close to the running rail bearing across bridges and to extend them 50 to 100 ft. beyond the bridge ends where they are flared and usu-



Typical Frog Point Nosing for Bridge Guard Rails



Typical Cast Nosing for Bridge Guard Rail



Typical Bridge Guard Rails and Nosing

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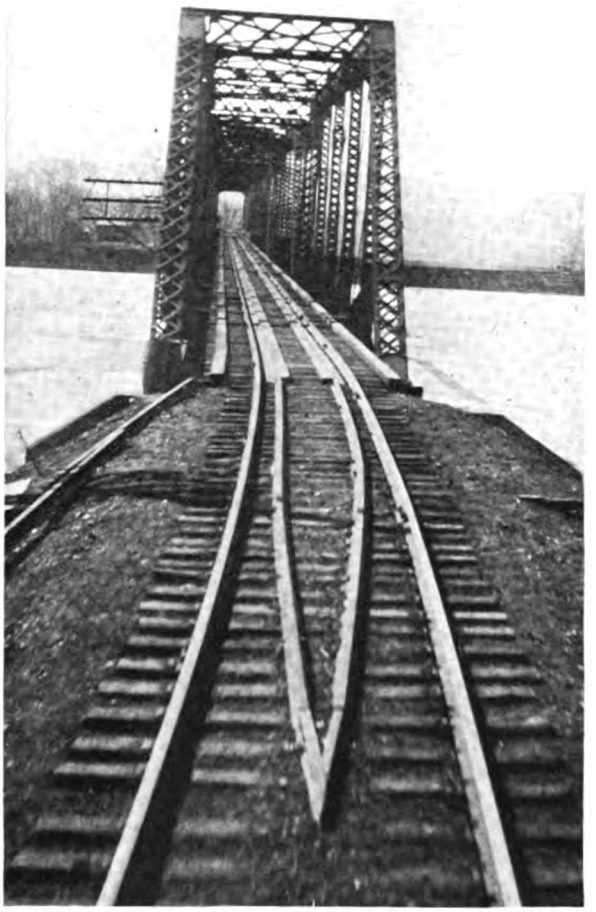
ally terminate in nosings in the center of the track, or are depressed without flare to avoid catching objects dragging from trains. A third bridge guard rail is sometimes placed in the center of the track as a further protection against damage from derailments and to prevent derailed cars from passing over the side of the structure. Bridge guard rails



Guard Rails in Place on a Steel Bridge

should be well spiked to the ties and provided with rail joints. They are preferably of the same height or not more than one inch lower than the running rails, and are recommended for use on all open-floor bridges and on the outside tracks of all solid-floor bridges and similar structures longer than 20 ft. in main line tracks and in other tracks where train speeds are 20 miles per hour or higher. The bond timbers of open-floor bridges are also sometimes known as outside guard rails. They are usually 6 in. thick by 8 in. wide, sometimes shod with angle iron at their upper inside corners, usually bolted or fastened with lag screws to every third or fourth tie and are laid farther from the running rail than the inside guard rail so that a derailed wheel will strike the latter first.

The A. R. E. A. makes the following recommendations covering the use of guard rails for wooden bridges and trestles:

1. It is recommended as good practice to use guard timbers on all open-floor bridges. They should be so constructed as to properly space the ties and hold them securely in their places.

2. It is recommended that the guard timber and the inner guardrail, when used, be so spaced in reference to the track rail that a derailed wheel will strike the inner guardrail without striking the guard timber. The inner guardrail should not be higher or over 1 in. lower than the running rail.

3. It is recommended as good practice to extend guardrails beyond the ends of the bridges for such distance as is required by local conditions, but not less than 50 ft.; that inner guardrails be fully spiked to every tie, and spliced at every joint; that the inner guardrails be some form of metal section and that the ends be beveled, bent down, or otherwise protected against direct impact with moving parts of equipment.

4. It is recommended as good practice to use inner guardrails on all open-floor and on the outside tracks of all solid-floor bridges and similar structures longer than 20 ft. in main-line tracks, and on similar bridges and structures in branchline tracks on which the speed of train is 20 miles per hour or more.

Curve Guard Rail

A rail or line of rails placed parallel to the running rails on curved track at the proper flangeway distance from the rail where protection is desired, to guide the flanges of wheels and to help prevent derailments due to sharp curvature.

The classes of derailments most frequent on curves are those due to top heavy and unequally loaded cars, such as local or peddler refrigerator cars, in which meat carcasses are hung from hooks in the roof beams; flat cars loaded to the limit of height and poorly staked; cars with trucks that "do not curve easily" on account of defective side bearings or from other causes; wheels with sharp flanges or wheels loose on the axle; locomotives with flangeless middle driving wheels; locomotive tenders with high water tanks; or track in improper surface and line or with insufficient fastenings. It is probable that high speed on curves is frequently a contributory cause of derailment. On curves where such dangers exist it is common practice to install a guard rail all the way round the curve near the inside running rail at the proper guard rail distance from the gage side of the inside rail to prevent the opposite wheels from mounting the outside rail. On very sharp curves another guard

Typical Curve Showing Inside Guard Rail

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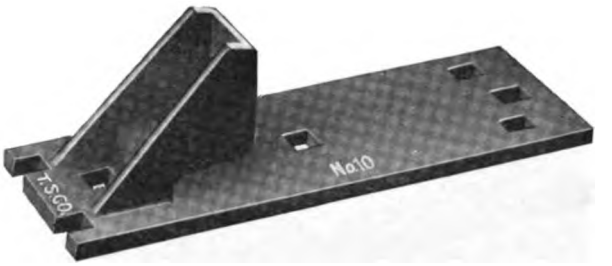
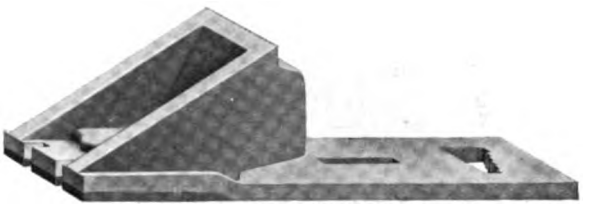
rail is also installed on the gage side of the outside rail to prevent the derailment of flangeless drivers. Curve guard rails are usually spiked to the ties, bolted to the running rails with separators between and braced with ordinary rail braces or sometimes with special guard rail braces. They are frequently of lighter section than the running rails.

GUARD RAIL BOLT. A threaded steel bolt used to hold the running rail, separator block and guard rail together, passing horizontally through corresponding holes in the three sections and held by a nut on the guard rail side. Usually the nut is held tight by a nut lock or cotter or both. The guard rail bolt is usually 1 in. to 1⅜ in. in diameter, about 8 in. long and is frequently heat-treated to obtain the requisite strength.

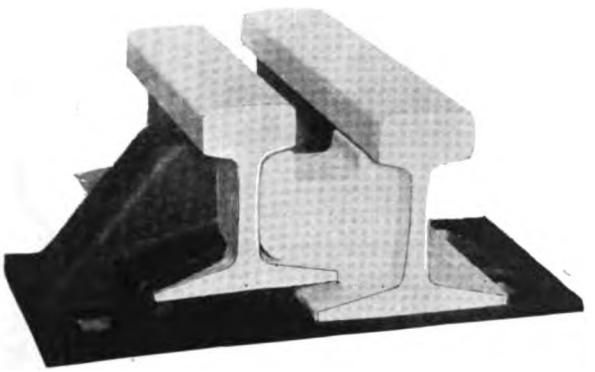
GUARD RAIL BRACE. A metal shape similar to the ordinary rail brace but usually larger and stronger, the head of which fits the contour of the side of the rail while the diagonal backbone declines to the foot which is punched for two or more spike



Trasco Rail Brace and Tie Plate
The Track Specialties Co.
(See Page 817)



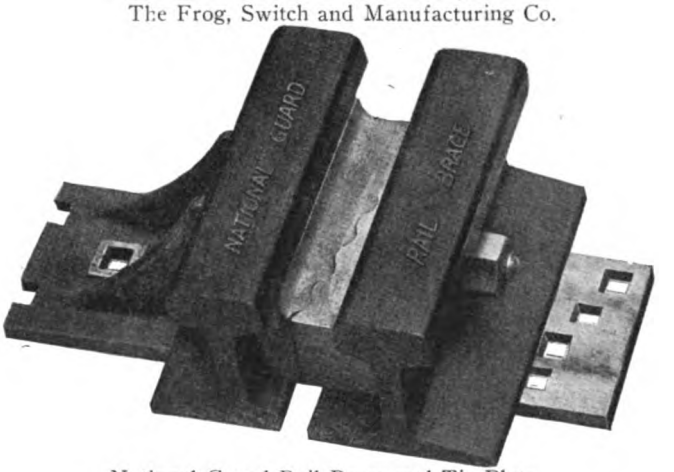
The Vaughan Tie Plate Guard Rail Fastener
The M. W. Supply Co.



Two Types of Positive Guard Rail Braces and Tie Plates
The Positive Rail Anchor Co.

Rail Brace and Tie Plate
The Frog, Switch and Manufacturing Co.

Two Types of Rail Braces and Tie Plates
The Frog, Switch and Manufacturing Co.



National Guard Rail Brace and Tie Plate
The Q & C Co.
(See Page 777)

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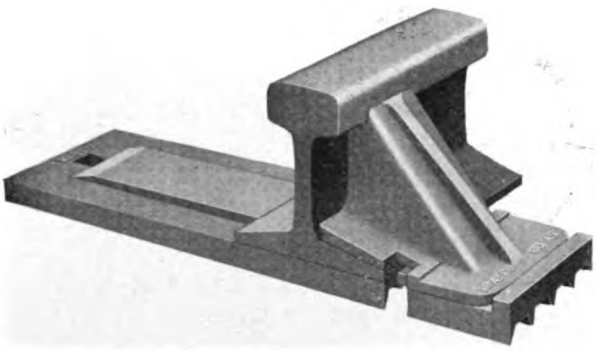
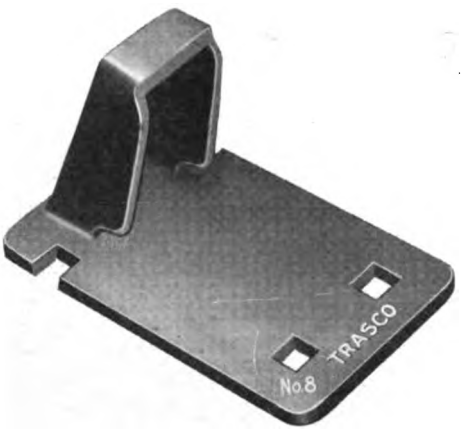
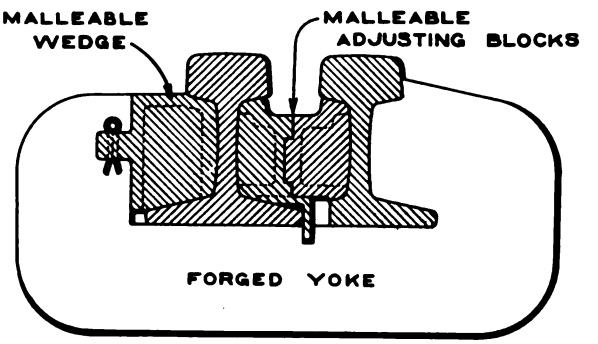


Trasco Guard Rail Clamp
The Track Specialties Co.
(See Page 817)

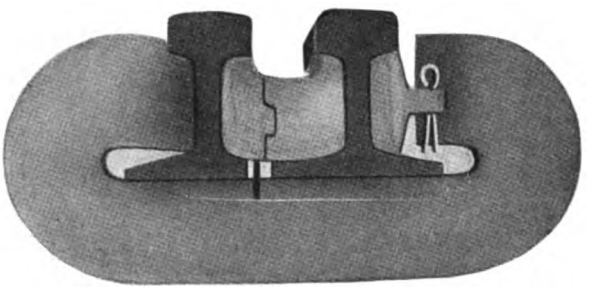


Two Types of Trasco Rail Braces and Switch Plates
The Track Specialties Co.
(See Page 817)



Guard Rail Clamp
The Pettibone Mulliken Co.
(See Page 773)

Positive Guard Rail Brace and Tie Plate
The Positive Rail Anchor Co.



Wharton Guard Rail Clamp
Wm. Wharton Jr. & Co., Inc.
(See Page 838)

holes. The brace is placed on the tie at right angles to the rail, with the head bearing against the rail and the foot spiked to the tie on the inside of the track to support the head of the guard rail and prevent it from canting inward. Guard rail braces are sometimes adjustable or they may be made integral with guard rail plates. See Rail Brace.

GUARD RAIL CLAMP. A device for holding a guard rail and the adjacent running rail in their correct positions relative to the frog point. The guard rail clamp usually consists of a yoke which fits beneath and around the bases and webs of both rails, an adjustable two-piece separator which fits between the rails, and a wedge which fits between the clamp and one of the rails and holds the device

Universal Guard Rail Clamp
The Q & C Co.
(See Page 777)

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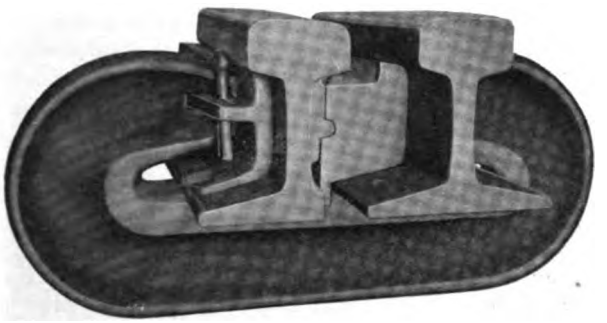
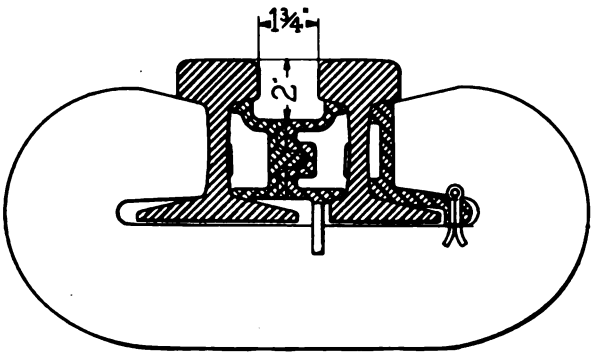


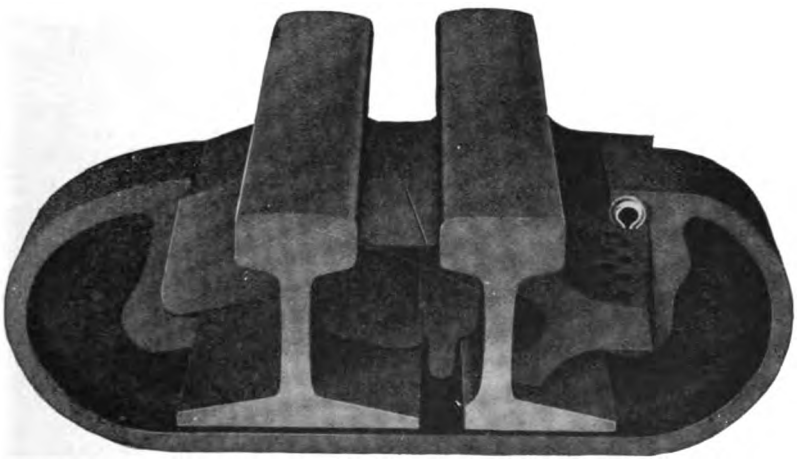
Anchor Guard Rail Clamp
The M. W. Supply Co.

Reading Guard Rail Clamp
The Reading Specialties Co.

Ramapo Guard Rail Clamp
The Ramapo Iron Works
(See Page 785)



Morden Guard Rail Clamp
The Morden Frog & Crossing Works
(See Page 752)

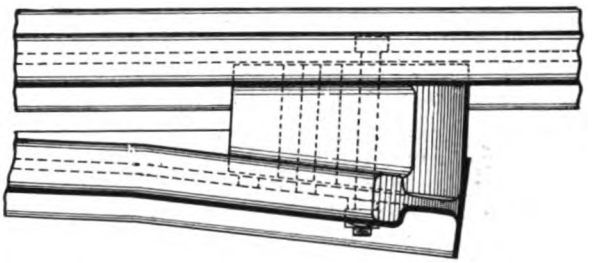


Weir Guard Rail Clamp
The Weir Frog Co.

in position by wedge action and a cotter fastener. Some types of clamps have additional filler blocks, variously fastened; other types are cast in manganese steel with two or more parts in combination, but all follow the general form described. See Guard Rail.

GUARD RAIL, CURVE. A rail or a line of rails placed parallel to the running rails in curved track to so guide the flanges of wheels as to prevent derailments and damage resulting therefrom. See Guard Rail.

GUARD RAIL END BLOCK. A metal device, usually a special malleable iron casting designed to hold the end of the guard rail in position by filling the space between the running rail and the flared end of the guard rail, in which position it is secured by means of 1 in. to 1½ in. bolts which pass horizontally through corresponding holes in



Adjustable End Block for Guard Rails
The Morden Frog & Crossing Works

the block and the webs of the running rail and the guard rail. The end block is usually designed to serve also as a foot guard. The flare of the guard rail may be made in part on a straight line, in which case the space between it and the running rail lends itself readily to the application of a wedge-shaped end block, which shape has been utilized to permit of adjustment. End blocks are also made as parts of one-piece cast manganese steel guard rails.

GUARD RAIL PLATE. A special tie plate strong enough and long enough to carry the bases of the running rail and the guard rail in their relative positions. Guard rail plates vary in length according to the rail base widths, the flangeway and

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flare widths and the adjustment features, if any. Some guard rail plates are designed with special shoulders or other devices to transmit the side thrust of wheel flanges from the gage line of the guard rail head to the running rail, so that the load on the wheel will help to hold the guard rail in position.

GUIDE, REACH ROD (Slip Switch). A casting fastened on a tie to hold the reach rod in position.

H

HALF COCK (Switch). When neither switch point is against a running rail the switch rails are said to be at half cock. See Switch Point.

HALF INCH POINT (Frog). See Actual Point of Frog.

HARVEY GRIP THREAD (Track Bolt). A ratchet-shaped lock thread, cold-pressed on a soft steel bolt and under-cut 5 deg. on the bearing side. This thread gives to the extent of the under-cut when engaged by a nut thread with a bearing surface at right angles to the axis of aperture, thus forcing the metal of the bolt threads into the outer recesses of the nut threads with a locking action. See Track Bolt.

HAUL (Roadway). The distance from the natural location of material to the spot where it is placed in the roadway formation.

Grading contracts usually provide for extra compensation on account of the expense of moving materials long distances. The limit of free haul is frequently set at 1000 ft., which is calculated from the center of gravity of the excavation to the center of gravity of the embankment or other place of deposit. Material hauled beyond the free haul limit is known as overhaul and is calculated in cubic yards moved through the overhaul distance multiplied by that distance in units of 100 ft.

HEAD BLOCK. One or two long ties which carry the points of the switch rails, and extend far enough to one side of the track to form a base to which the switch stand is usually spiked; though in some cases switch stands are set on bases independent of the head blocks in order to prevent the switch lamp from shaking, due to the jar from passing trains. Head block timbers are from 12 ft. to 16 ft. long, the standard track clearance adopted being a governing factor.

Many western railways use head blocks 14 ft. long and some have a 16 ft. standard, while the tendency on the eastern lines is to restrict the length to 12 ft. Single piece head blocks are about 8 in. by 14 in. in section, while the two-piece type usually consists of ties of the section of the other switch ties of the set. See Tie, Cross. Also Switch Stand.

HEAD LOCK. A special washer or other device designed to prevent the head of a bolt from turning, used on the main bolts of many crossing frogs.

HEAD ROD. See Switch Rod, No. 1.

HEAD SEPARATION (Switch). The point of divergence of the heads of the switch rail and the stock rail of a switch.

HEAD SHOE (Switch). A flat iron or steel casting or plate spiked on a head block to support the ends of the movable and fixed rails of a stub switch.

The movable rail end faces the two fixed rail ends at the center line of the shoe. One-half of the head shoe holds the ends of the fixed rails rigidly in place between clips which extend up over the flanges to their webs. The other half of the shoe supports the movable rail, the side stops limiting the throw of the switch rail from gage to gage of the fixed rails. Sometimes a ridge over which the movable rail must be lifted occupies the space between the gage limits to insure its moving into proper position. See Switch, Stub.

HEAD OF SWITCH CLIP. That portion of the switch clip which fits against and is bolted to the reinforcing strap or the web of the switch rail.

HEAVING. The lifting of the ground surface due to the expansive action of frost on the moisture in the soil.

In cooling, water contracts from the boiling point until it reaches its point of maximum density at 39.2 deg. F., while at lower temperatures it again expands as is evidenced by the fact that ice floats with 1/12 its volume above the surface. The sudden expansive force of freezing water is probably as much as 30,000 lb. per sq. in., being sufficient to heave track and masonry foundations and break water pipes. On account of the varying moisture content, ground and ballast heave irregularly in undulations. During long continued cold weather the frost strikes deeper each night, penetrating new strata and resulting in new upward movements in the direction of least resistance. Thus, ground that has heaved in the early winter will heave more if the cold weather continues, while ground that has not heaved in early winter may suddenly start rising late in the season. The changes in levels continue also as the frost goes out of the ground and are frequently accentuated by daily accumulations of moisture from melting snow which freezes at night. The permanent remedy for heaving is to drain the moisture from the ground, while the temporary and immediate expedient is to place shims of the required thickness under the rails in the sags to restore them to the proper relative surface.

HEEL BLOCK (Switch). A block which spans the joints and fills the space between the adjacent rails at the heel of a switch where there is not room for bolting and maintaining two adjacent joint bars. The heel block is drilled to correspond with the holes in the joint bars used to complete the double joint, the special bolts passing through the central heel block, the two rail webs and the two outside joint bars to hold all the parts firmly together.

HEEL END (Frog). The wide end of a frog point where the two diverging gage lines terminate.

HEEL EXTENSION (Frog). The extension of a manganese frog point which fills the space and acts as a joint bar between the heel rails of a manganese railbound frog or between the heel connecting rails of a manganese solid frog. It may also act as a heel riser.

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HEEL LENGTH (Frog). The distance between the actual point of frog and the heel, measured along the gage line of running rails.

HEEL LENGTH, THEORETICAL (Frog). The distance between the theoretical point of frog and the heel measured along the gage line of running rails.

HEEL OF FROG. The end of the frog farthest from the switch points.

HEEL OF SWITCH. That end of the switch rails farthest from the points.

HEEL PLATE. See Switch Plate.

HEEL RAIL (Frog). A rail extending from the manganese point to the heel end of a manganese railbound frog.

HEEL RISER (Frog). A sloped or beveled surface on the heel of a frog providing a rising approach for the false flanges of wheels entering from the heel end. See Heel Extension (Frog).

HEEL RISER BLOCK (Frog). A wedge-shaped, hard-faced metal block closely fitting the angle of the heel of the frog and having the top surface beveled or sloped downward away from the vertex of the frog so as to present a rising surface to the false flanges of wheels entering from the heel, to raise and carry worn wheel tires across and above the rail head to prevent flanges from cutting it. See Frog.

HEEL SLOPE (Switch). That part of a switch under which the riser plates are sometimes graduated to reduce the elevation at the heel of the switch.

HEEL SPREAD (Frog). The distance between the gage lines of the two point rails at the heel of frog.

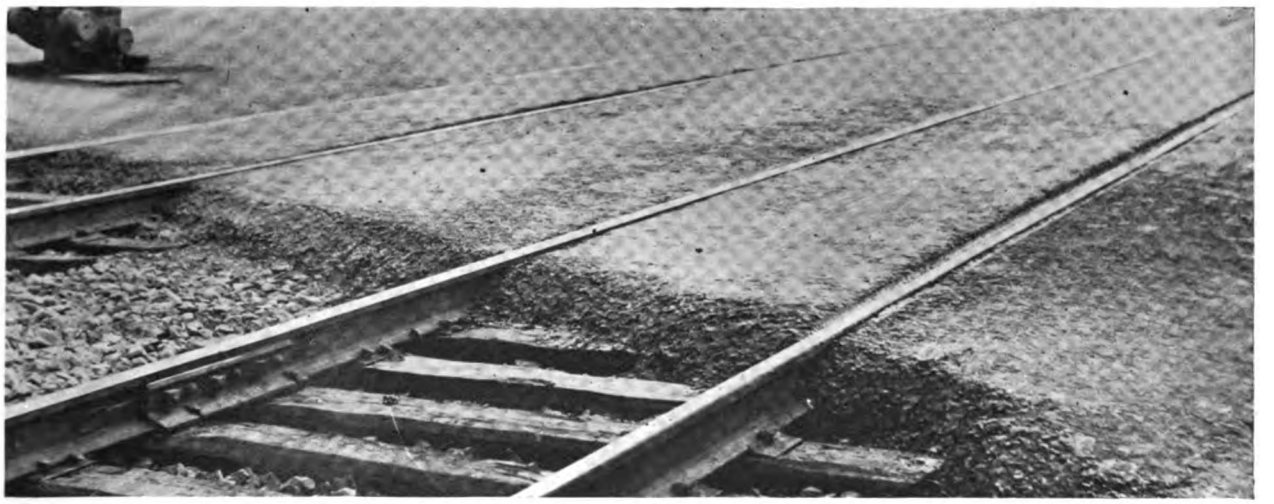
HEEL SPREAD (Switch). The distance between gage lines at the heels of the switch point rails. The standard heel spread is 6¼ in. See Switch.

HIGHWAY CROSSING, GRADE. The intersection of a public road with a railway track in the plane of the tops of the running rails.

Commonly the grade of the highway is raised as required within the limits of the railway right-of-way to the elevation of the tops of the running rails. There are many cases, however, where the highway approach grades continue outside the limits of railway property to either raise or lower the road to correspond with the grade of the railway

Highway Grade Crossing with Stone Block Paving

track. A grade crossing, however well situated, introduces an element of danger which is minimized, when the conditions permit, by a right angled crossing, straight alignments, level grades and unobstructed lines of sight on both railway and highway in all directions. A dangerous condition is frequently created by locating otherwise ideal crossings at acute angles. This practice results from locating highways on land lines regardless of other structures, as well as from the objections of highway authorities to deviating from the straight line highway and introducing reverse crossing approach curves which would necessitate reducing the speed of vehicles and frequently involve the purchase of extra right-of-way near the crossing. The first consideration in locating a grade crossing is, therefore,



Highway Grade Crossing with Bituminous Concrete Paving

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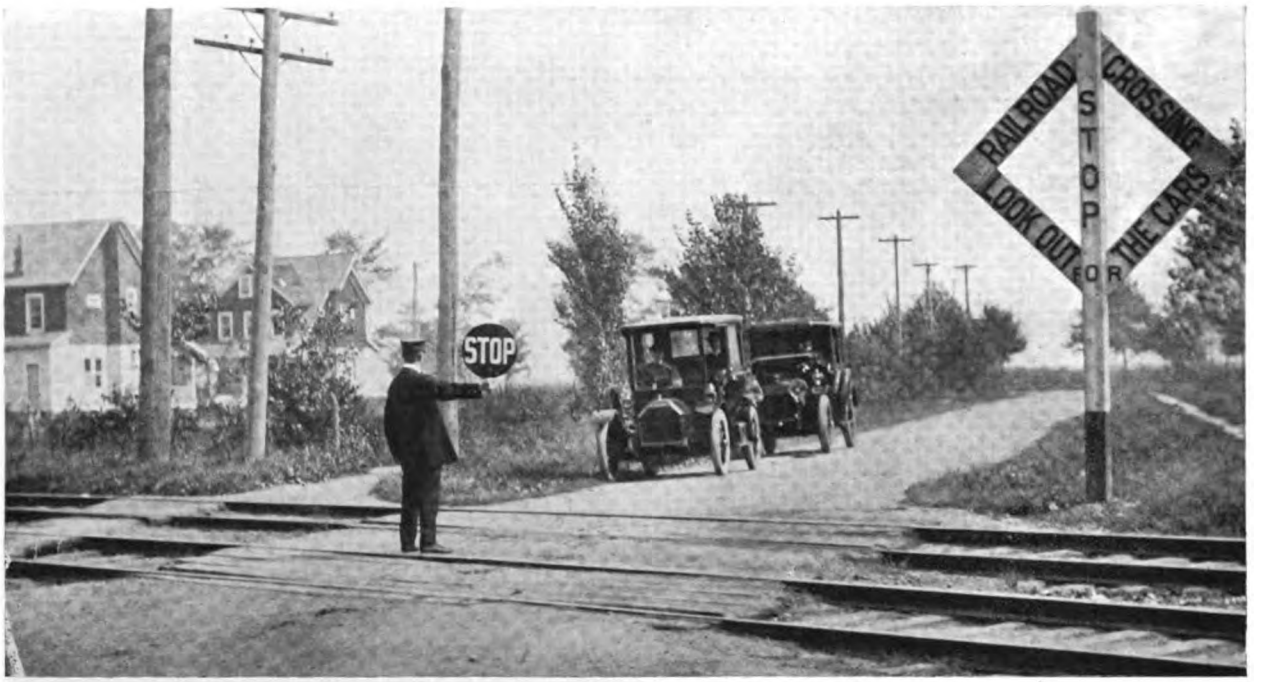
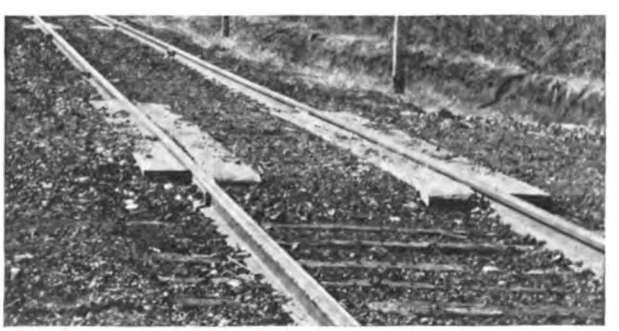
to cross the tracks at an angle of 90 deg. if possible, even though some sacrifice in alignment may be necessary. From the safety standpoint, highway crossing approach curves which interfere with fast driving are desirable, as the slowing down gives the driver an opportunity for observation before his vehicle is actually on the track. Other obstacles to the lines of sight, such as trees on the insides of railway or highway curves, mounds of earth, sidings where cars may stand, buildings, etc., commonly receive attention in ratio of their relative importance. Grade crossings located close together may sometimes be combined; or one may be eliminated in favor of another; or a change of location in a highway which follows the general course of, but crosses and recrosses the tracks, may be arranged to eliminate two or more crossings. Special attention to the grades of the railway is advisable, for it is not good practice to locate a crossing on or near the foot of a long descending grade where train speeds normally are high. Within the corporate limits of cities train speeds commonly are regulated by ordinance, though there is no uniformity of practice in this regard. Culverts commonly are required under country highway approaches to carry the water parallel with the railway tracks, while the paving usually conforms with that of the highway standard, and the crossing is planked between the rails.

Grade crossing protection is provided generally at dangerous and important highway or city street crossings, where it is not possible to deviate from the line of the street and where traffic on the street, or switching on the railway or both, demand something more effective than the approach and crossing signs of the ordinary country highway. The city street crossing is usually paved across the railway property and tracks, with materials identical with the paving on each side, the running rails being provided with flangeways made of rails laid on the side with the head against the web of the running rail; or of special castings set in the paving, either separate from or integral with the running rails. The construction of street crossings commonly involves drainage to storm water drains or sewers and permanent foundations usually of reinforced concrete on which a cushion of sand or other material is placed as a bedding for the cross ties, over which the paving is placed to the level of the top of the running rails of the railway track.

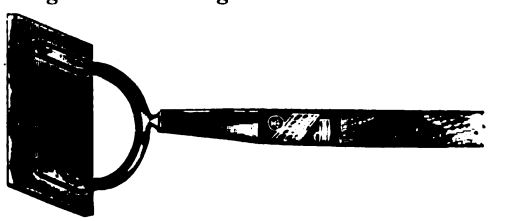


Planked Grade Highway Crossing



Planked Farm Crossing

HOE, SCUFFLING. A long handled push hoe for cutting and removing weeds.



Scuffle Hoe

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This hoe commonly consists of a thin rectangular, beveled steel blade, about 4 in. wide and 8 in. long, riveted crosswise on the lower end of a malleable iron bracket which terminates at its upper end in a handle socket. The bracket shank is bent at an angle of about 25 deg. from the axis of the 5 ft. wooden handle, so that when the blade rests flat on the ground the operator, without stooping, may readily grasp the handle and shove the blade ahead, scraping the surface of the ground to cut off weeds.

HOLD-DOWN (Frog). A two-piece metal device attached to a spring rail frog to prevent the movable wing rail from rising off the base plates on which it slides.

One part of the hold-down, called the horn, projects at right angles from a reinforcing strap riveted to the web of the wing rail. This projection is a close pressed fold in the strap about six inches long, which moves back and forth with the movement of the wing rail, inside an inverted U-shaped housing with only ¼ in. vertical play. The housing is fastened down on the base plate with four rivet head bolts installed with nut ends up. Usually the movable wing rail is held down by two of these devices. The hold-down is especially useful in freezing weather to prevent an accumulation of sand, snow or ice on the plates from raising the movable wing. See Frog.

HOLD-DOWN HORN (Frog). A metal plunger fastened to the movable wing rail of a spring rail frog which fits into a housing to prevent the wing rail from springing up.

HOLD-DOWN HOUSING (Frog). A metal cuff bolted to the base plate of a spring rail frog to hold the horn in proper position.

HOOD (Switch Lamp). A narrow flange of sheet metal placed around the upper half of the outside circumference of the lens to protect the glass. Snow and sleet clinging to the outside of the lens tend to obscure the light of a switch lamp. The purpose of the hood is to protect the lens from the elements as much as possible without obstructing the path of the rays.

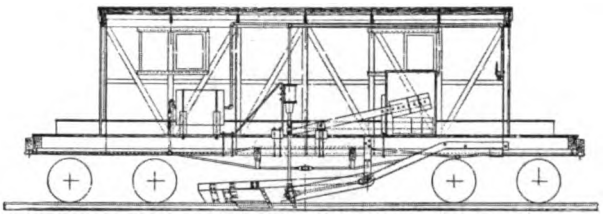
HOUSED SWITCH. A switch having one or both points protected by a housing when open. The housing consists of a bar supported upon chairs which covers and shields the switch point when in the open position.

HOUSING, CENTER (Slip Switch). A casting fastened to two adjacent ties to support and protect the center point throwing apparatus of a slip switch.

HOUSING, END (Slip Switch). A casting fastened to two adjacent ties to support and protect the end point throwing apparatus of a slip switch.

I

ICE CUTTER. A flanger car equipped between the trucks and beneath the floor with a toothed steel beam set on edge diagonally across the track between the rails and operated by means of compressed air which is lowered to loosen the hard snow and ice. A small flanger plow is placed close behind the ice cutter and is raised and lowered with it to clear the shattered ice from the track. The vertically depending teeth of the cutter, set about 6 in. apart, are chisel pointed tool-steel rods about 1 in. by 1 in. by 12 in., each fastened with two bolts to the front side of the bar. This machine is of special utility in yards to clear ice or snow which is too hard to be moved by means of the steel plates of snow plows. See Snow Plow. Also Flanger (Snow).

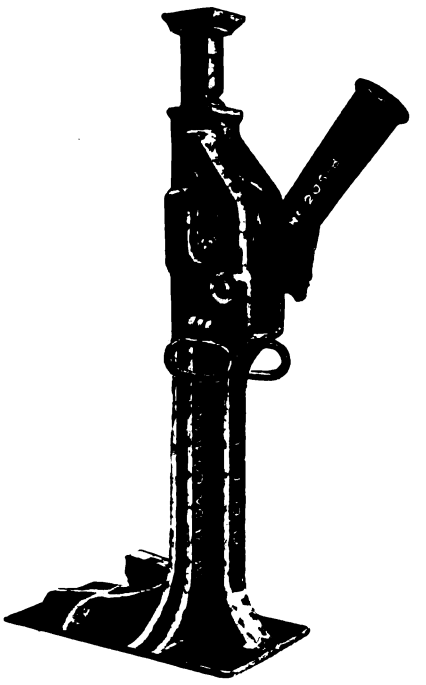


Ice Cutter Car
D. S. S. & A.

INSIDE CURVE RAIL (Slip Switch). One of the two innermost rails of a slip switch set, connecting the heels of opposite end-point rails. The inside curve rails on the oppostie sides of a double slip switch form converging curves.

J

JACK. A portable tool variously constructed for exerting great pressure, or for raising, moving and temporarily sustaining heavy loads such as track, bridge members, houses, etc. This contrivance usually consists of a broad-based, hollow, pillar-like metal casting enclosing a steel bar which is raised and lowered by means of a lever, a screw or some combination of devices operating on one or both of these principles. Ordinarily the upper portion of the jack frame bears a hinged cast steel lever socket



Ballasting Track Jack
The Buda Co.
(See Page 659)

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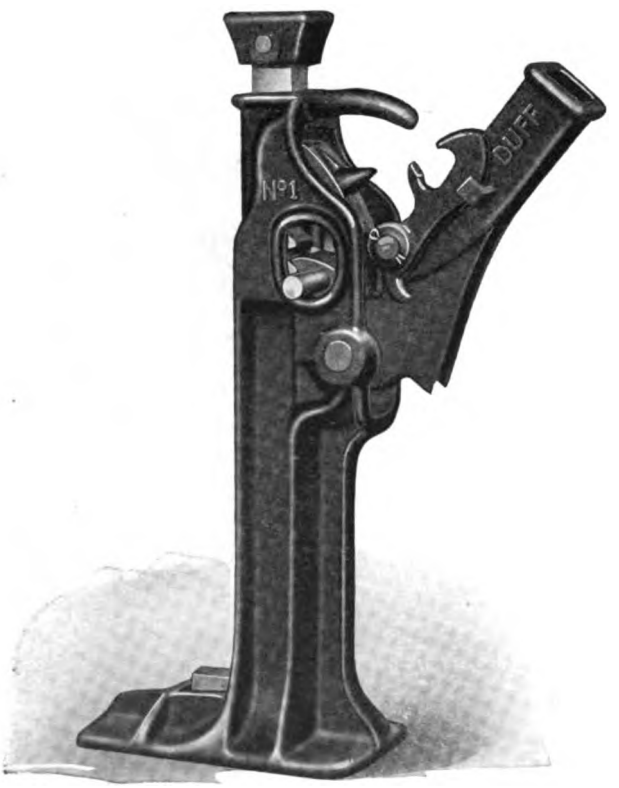
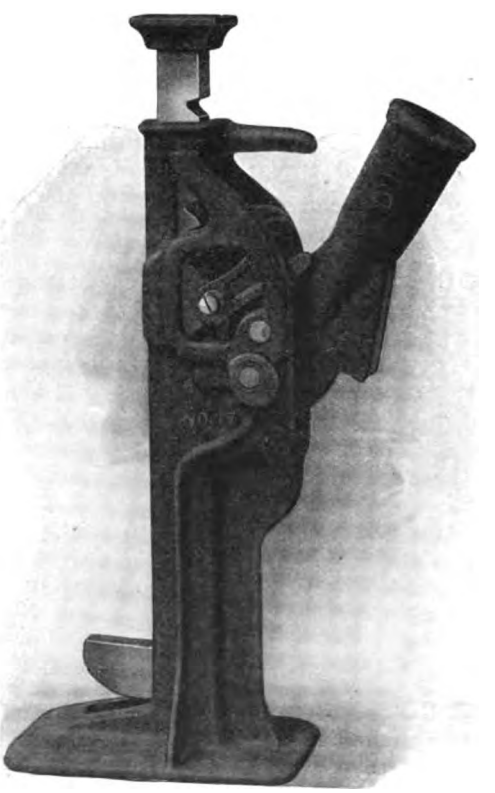
Ballasting Jack
A. O. Norton, Inc.
(See Page 759)

Albany Ratchet Jack
The L. J. Kelly Manufacturing Co.



Barrett Double Acting Track Jack
The Duff Manufacturing Co.



Barrett Single Acting Track Jack
The Duff Manufacturing Co.

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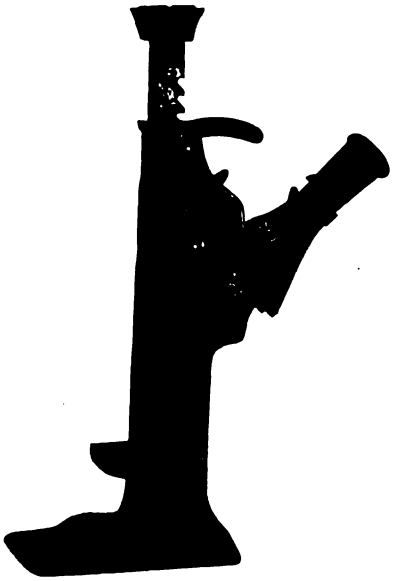
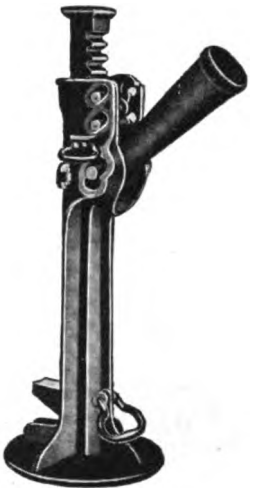


Automatic Lowering Jack
The Joyce, Cridland Co.

Trip Jack
The Buckeye Jack Manufacturing Co.



Plain Ratchet Lever Jack
The Joyce, Cridland Co.

Simplex Track Jack
Templeton, Kenly & Co., Ltd.
(See Page 818)

Simplex Surfacing, Track and Ballast Jack
Templeton, Kenly & Co., Ltd.
(See Page 818)

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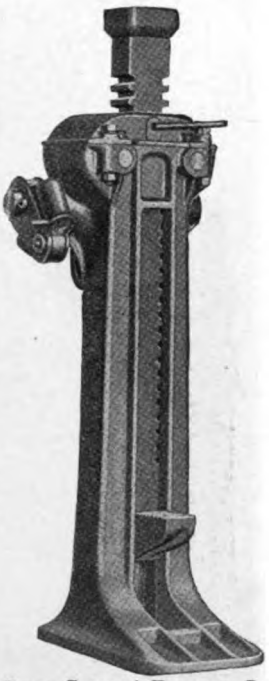
Buda Double Acting Track Jack
The Buda Co.
(See Page 659)

Duff Geared Automatic Lowering Jack
The Duff Manufacturing Co.



Rees General Purpose Jack
The Iron City Products Co.

Buda "Postop" Ball-bearing Bridge Jack
The Buda Co.
(See Page 659)

Simplex Industrial Jack
Templeton, Kenly & Co., Ltd.
(See Page 818)

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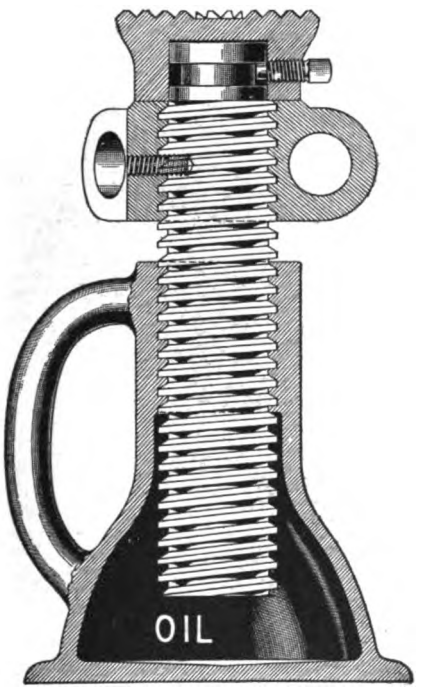
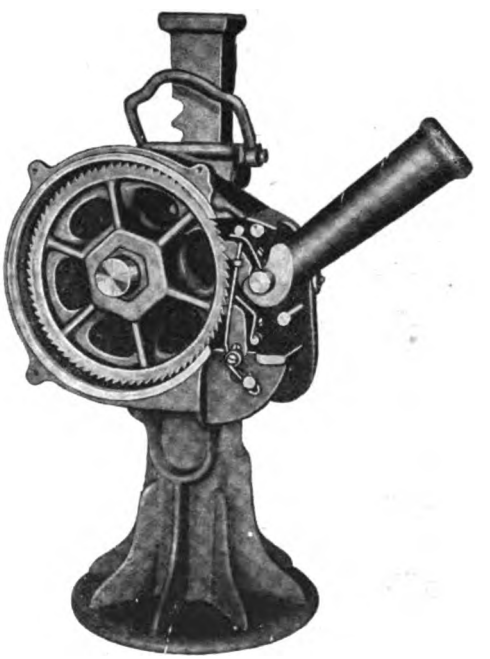
Geared Jack
A. O. Norton, Inc.
(See Page 759)

The Doughboy Jack
The McKiernan-Terry Drill Co.



Bell-Base Screw Jack
The Joyce, Cridland Co.



Full Automatic Geared Jack
The Joyce, Cridland Co.

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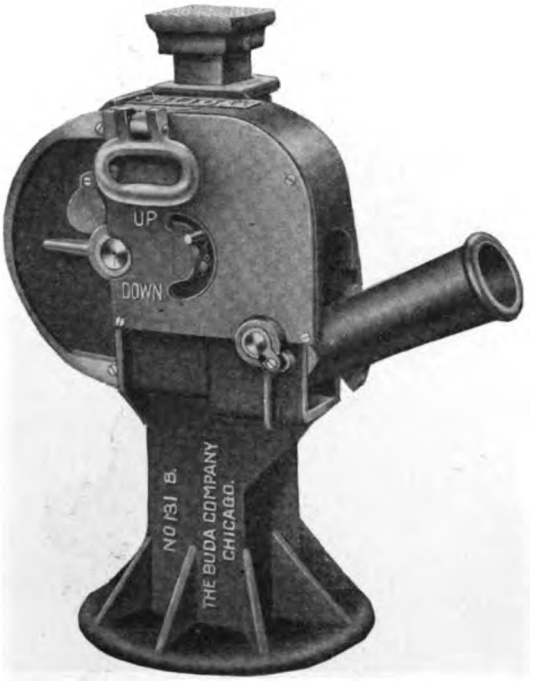
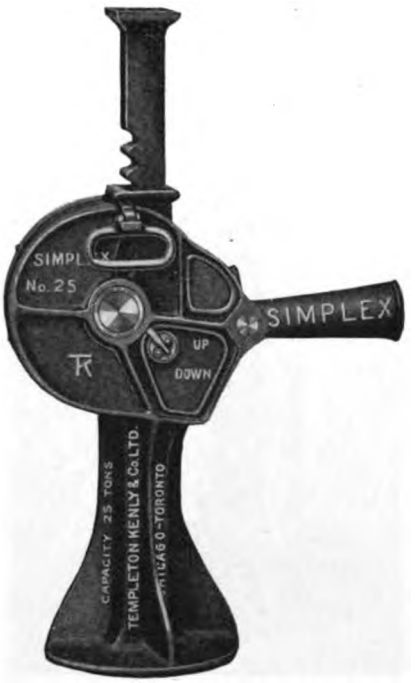
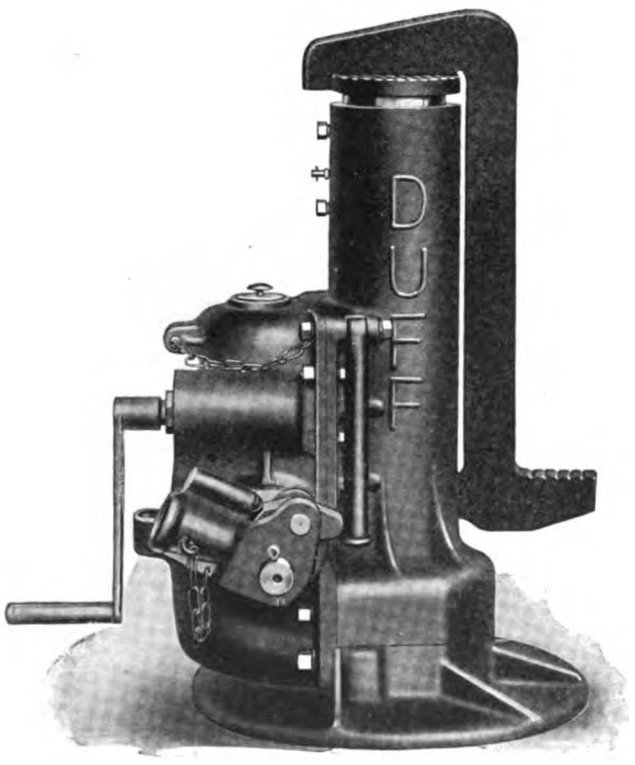


Buda Geared Ratchet Jack
The Buda Co.
(See Page 659)



Simplex Geared Jack
Templeton, Kenly & Co., Ltd.
(See Page 818)



Duff Ball-Bearing Jack
The Duff Manufacturing Co.

Duff Traversing Jack
The Duff Manufacturing Co.

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Simplex Emergency Jack
Templeton, Kenly & Co., Ltd.
(See Page 818)

attached to the mechanism which engages and moves the lifting bar or column when force is applied to the lever.

The greatest distance through which a load may be lifted or moved is limited by the height of the frame and the length of the bar, though the usual lift is not more than a few inches. When the foundation is soft and pliable, it is common practice to prepare a crib of blocking on which to set the jack, which should have an unyielding foundation; or if it must be set on the ground it is usual to scrape the loose top soil away, leaving a firm level spot as a seat for the base. While the capacity of a jack may be one or many tons it should be in proper ratio to the length of lever, the limit of available power and the uses for which the tool is designed. Those used in railway maintenance will commonly lift from 5 tons to 20 tons or more. Usually these machines are designed to move loads through successive small steps commonly an inch to two at a time to the limit of the working distance.

Extreme lifts are rarely advisable, better practice being frequent blocking under the jack.

Of the various jacks used for railway maintenance, the screw, ratchet lever and friction clutch types have lifting capacities up to 20 tons, while the ball-bearing, geared screw and geared ratchet jacks are used for heavier work. The lifting bar, screw, gears, pinions, pawls, trunnion and lever socket are preferably made of steel while the frame and base may be made of iron or steel. The lever sockets are made either round or rectangular in section as desired, to fit a round wooden handle or a square shanked steel lever.

JACK, BALL-BEARING. A heavy duty jack consisting of a steel screw encased in a dust-proof sliding steel sleeve which is supported by a ball-bearing case resting on a gear near the top of the screw. The screw which passes down through a nut is revolved to raise the sleeve by means of a ratchet lever which engages the teeth of a pinion and a gear meshed with a screw gear. The jack is lowered by changing the tilt of a pawl at the fulcrum and by operating the lever arm as in raising the sleeve.

JACK, FRICTION CLUTCH. A jack used to raise and sustain loads by means of the grasping power of circular metal rings surrounding a smooth bar. This type of jack has a similar frame and fulcrum but differs from the ratchet lever jack in that its lifting bar is round and is operated by two lifting rings, connected by a hinged hanger to the top of the lever arm. The diagonally-bored lifting rings of the friction clutch encircle the lifting bar at an acute angle so that they clutch or grip it with opposite edges when released from the lever. The operator may lower the jack by lifting slightly and disengaging the top ring from the lifting bar, at the same time pressing down on the tail piece to disengage the lower ring, thus allowing the bar to drop any desired distance. This style of jack permits raising a load with one movement to any height within the limits of the lifting bar, while other types raise the load only the distance between two teeth.

Buda Friction Jack
The Buda Co.
(See Page 659)

JACK, GEARED RATCHET. A ratchet jack used in wrecking or bridge work, etc., having a square sectioned, steel, machine-cut, toothed, lifting bar encased in a heavy iron or steel frame fixed on a broad base and operated by a pinion, gear and pawls. The pinion which lifts the bar is moved by a gear operated by the lever arm and pawls. The lifting bar may be lowered by means of an eccentric in the side of the frame.

JACK, SCREW. A jack used to raise and sustain dead loads during the construction or erection of buildings, boilers, machinery, bridges, etc. This device usually consists of a steel lifting screw which engages the female threads of and moves inside a vertical broad-based, steel frame, the screw head being commonly a malleable iron cap with a horizontal eyelet hole through which a short steel bar may be thrust and twisted to rotate and operate the screw to obtain any difference in elevation from a fraction of an inch to the extent of the threads.

JACK, TRACK, RATCHET LEVER. A jack used to raise and sustain track while the ballast is being placed or tamped, or the ties renewed. It commonly consists of a square-sectioned, steel,

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machine-cut, toothed lifting bar usually having a flat-topped malleable iron cap on the upper end and a rail-lifting claw projecting from the lower end, its body being loosely encased in a steel or iron frame having a broad rectangular base. The lifting bar is raised by means of a lever arm, an attached pawl and a top catch, the pawl being fastened to the fulcrum while the top catch is fastened to the end of the lever which engages the notched teeth on the front edge of the bar. This type of jack may be either single acting or double acting, the single acting style raising the lifting bar only one notch or the distance between two teeth on the downward stroke of the lever arm, while the double acting jack raises the lifting bar one-half notch on both the upward and downward strokes of the lever arm. With either type of jack the load can be dropped by bearing down slightly on the lever arm and releasing the pawls, or it may be lowered gradually by moving an eccentric on the side of the frame which reverse the action of the pawls. Ratchet lever jacks are sometimes used to raise loads diagonally as well as vertically, in which case they are furnished with jointed bases or caps or both.

JACK-KNIFE SWITCH STAND. A switch operating device consisting essentially of three parallel horizontal bars of steel, usually about 3 ft. long and placed at right angles to the track on the headblock of the switch, the outside bars forming a fixed frame between the sides of which the middle lever may be moved in a vertical plane, around a fulcrum formed by a rivet or bolt which passes horizontally through the frame and the lever about 4 in. from the end of the lever which is attached to the connecting rod. The throwing of the lever from its closed position in the frame, through an arc of 180 deg. moves its bottom end with the connecting rod so as to throw the switch. This is a common switching yard and industrial track type.

JOINT BAR. A steel angle bar or other shape used to fasten together the ends of contiguous rails in a railway track. They are used in pairs, one on each side of the rail and they are designed to fit the side and base of the rail closely, in which position they are held by means of track bolts.

A modern development is the heat treated and quenched carbon steel and alloy steel joint bar now largely used where this treatment is necessary to obtain the necessary strength and toughness of the metal. For these processes the A. R. E. A. has formulated the following specifications for high carbon steel joint bars:

Basis of Purchase.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the joint bars have been made in accordance with the terms of the specifications.

2. All tests and inspection shall be made at the place of manufacture prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Material.

3. Material for joint bars shall be steel, made by the open-hearth process.

Chemical Properties.

4. The chemical composition of each melt of steel from which joint bars are manufactured shall be within the following limits:

Phosphorus, per cent, maximum 0.04.

5. The manufacturer shall furnish the inspector a complete report of ladle analysis, showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 4.

Physical Properties and Tests.

6. Joint bars shall conform to the following physical requirements:

(a) Tensile strength, lb. per sq. in. minimum, 85,000.

(b) Elongation, per cent in 2 in., minimum, 16.

(c) Cold bending without fracture on the outside of the bent portion through 90 deg. around an arc the diameter of which is three times the thickness of the test piece.

7. All test pieces shall be cut from finished bars.

(a) Standard ½ in. by 2-in. specimens, as adopted by the American Society for Testing Materials, shall be used for tension test.

(b) The bending test specimen shall be ½ in. square in section, or a rectangular bar ½ in. thick, with two parallel faces as rolled.

8. The different sections of joint bars shall be rolled to dimensions specified in the drawing furnished by the purchaser. No variation will be allowed in the dimensions affecting the fit and the fishing spaces of the rail. The maximum camber on either plant shall not exceed 1/32 in. in 24 in.

9. The joint bars shall be sheared to the length prescribed by the purchaser and shall not vary therefrom by more than ⅛ in.

10. (a) All joint bars shall be punched, slotted and shaped at a temperature of not less than 800 deg. Centigrade (1470 deg. Fahrenheit).

(b) All bolt holes shall be punched in one operation, without bulging or distorting the section, and the bars shall be slotted for spikes when required, in accordance with the drawings, the slotting being done in one operation; a variation of 1/32 in. in the size and location of the holes being allowed.

11. All joint bars must be finished smooth and true, without swelling over or under the bolt holes, and must be free from flaws, seams, checks or fins, and the fishing angles must be fully maintained.

12. The manufacturer's identification symbol, the kind of material, the month and year rolled and the number of the design, shall be rolled in raised letters and figures on each bar. The number of the melt shall be plainly stenciled on each lot of joint bars.

Inspection.

13. The joint bars from each melt shall be piled separately until tested and inspected by the purchaser's inspector. One joint bar for the tension test shall be selected by the inspector for each melt represented in finished bar, of by agreement the specimen for the tension test may be cut from the bar as rolled. One joint bar for the bending test shall be selected by the inspector from each lot of 1000 bars or less presented.

Specifications for Quenched Carbon and Quenched Alloy Steel Joint Bars

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the joint bars have been made in accordance with the terms of the specifications.

Place for Tests.

2. All tests and inspection shall be made at the place of manufacture, prior to loading, and shall be so conducted as not to interfere unnecessarily with operation of the mill.

Rejection at Destination.

3. Joint bars which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer, who shall pay the freight charges both ways.

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Material.

4. Material for joint bars shall be steel made by the open hearth process or an acceptable alloy steel.

Chemical Properties.

5. The chemical composition of each melt of steel from which joint bars are manufactured shall be within the following limits:

Carbon, per cent.....0.42 to 0.55
Phosphorus, per cent, maximum..... 0.04

Note.—In the event of nickel and chromium being present to the extent of 1.00 per cent and 0.35 per cent respectively, these elements will be considered as the equivalent of 0.07 per cent of carbon in the above requirements.

6. The manufacturer shall furnish the inspector a complete report of ladle analysis showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material. The purchaser may make a check analysis from the finished material which shall conform to the requirements of Section 5.

Physical Properties and Tests.

7. Joint bars shall conform to the following physical requirements:

	Quenched Steel.	Alloy Steel.
(a) Tensile strength, lb. per sq. in., minimum	100,000	110,000
(b) Elastic limit, lb. per sq. in., minimum	70,000	85,000
(c) Elongation, per cent in 2 in., not less than	1,600,000 / Ten. Str.	3,500,000 / Ten. Str.
Minimum, 12 per cent.		
(d) Reduction in area, per cent not less than		
Minimum, 25 per cent.		
(e) Cold bending of the quenched bar without sign of fracture on the outside of the bent portion through 90 deg. around an arc, the diameter of which is three times the thickness of the test specimen.		

8. All test specimens shall be cut from finished bars.

(a) The tension test specimens shall be about 4¼ in. long with threaded or unthreaded ends, and with the central 2-in. length turned to a ½ in. diameter, in accordance with the form and dimension for dimension test specimens of the American Society for Testing Materials.

(b) The bend test specimens shall be ½ in. square in section or a rectangular bar ½ in. thick with two parallel faces as rolled.

(c) The elastic limit shall be determined by the use of the Berry strain gage, or similar instrument, and will be the load when the elongation shows a change in the rate of stretch, the machine being operated at not more than ¼ in. per minute. After the elastic limit is reached the speed shall not exceed 2 in. per minute.

Quenching.

9. (a) Joint bars shall be quenched in oil, or water if so specified, from a temperature of about 810 deg. Centigrade (1490 deg. Fahrenheit) and shall be kept in the bath until cold enough to be handled. A group thus treated is known as a quenching charge.

(b) Material which requires quenching in water will be acceptable at the option of the purchaser, provided it meets the requirements of the specification in all other respects.

General Requirements.

10. Joint bars shall be rolled to dimensions specified in drawing furnished by the purchaser. No variation will be allowed in the dimensions affecting the fit and the fishing spaces of the rail. The maximum camber in either plane shall not exceed 1/32 in. in 24 in.

11. Joint bars shall be sheared to the length prescribed by the purchaser and shall not vary therefrom by more than ⅛ in.

12. (a) All joint bars shall be punched, slotted and shaped at a temperature of not less than 800 deg. Centigrade (1470 deg. Fahrenheit).

(b) All bolt holes shall be punched in one operation without bulging or distorting the section, and the bars shall be slotted when required for spikes in accordance with the purchaser's drawing, the slotting being done in one operation. A variation of 1/32 in. in location of the holes will be allowed.

13. All types of joint bars shall be finished smooth and true without swelling over or under the bolt holes, and shall be free from flaws, seams, checks or fins. The fishing angles shall be fully maintained.

Branding.

14. The rolled bar shall be branded or marked for identification in the following manner and a portion of this marking shall appear on each finished joint bar:

(a) A portion of the name of the manufacturer, the year of manufacture, the numbered design and the kind of material shall be rolled in raised letters and figures on the outside of the bars.

(b) The letters "O H" shall be used to indicate "Open-Hearth Steel."

(c) The letter "Q" shall be used to show that the joint bars have been "quenched." If the joint bars are also tempered, the letters "T" shall be used to show that they have been "quenched and tempered."

(d) The number of the melt shall be plainly stenciled on each lot of bars.

Inspection.

15. The joint bars from each melt or heat treatment lot shall be piled separately until tested and inspected by the inspector. One joint bar for tension test shall be selected by the inspector for each melt or heat treatment lot represented in finished bars. One joint bar for bend tests shall be selected by the inspector for each lot of 1000 bars or less presented or from each heat treatment lot.

JOINT BAR DRILLING. The provision of suitable holes at the ends of a frog to receive the joint bar bolts. In specifying the joint bar drilling it is customary to give the distance from the end of the frog to the center of the first hole, the distance center to center of the holes, the diameter of the holes and the distance from the base to the center of the holes. The joint bar holes are customarily located in the center line of the web, half way between the underside of the head and top of the flange of the rail.

JOINT BAR, HEEL (Switch). A special joint bar sometimes used on the gage side of the rail joint at the heel of a split switch to accommodate the movement of the switch rail. The heel joint bar may be bent laterally and held away from the web of the rail by washers, or a portion of the foot of the bar may be removed to provide the necessary clearance.

JOINT PLATE (Slip Switch). A special long tie plate designed to protect the tie and distribute the loads from the two adjacent ends of the switch rail and stock rail of a slip switch.

K

KNUCKLE RAIL (Slip Switch). A kinked stock rail against which the center points of a movable slip switch are alternately thrown. It is laid with the apex of the kink midway between the two movable points, with a leg extending each way from the middle in line with the end switch point to which it is joined, thus serving as a portion of the running rail of each of the two tracks and corresponding in function to an obtuse angle crossing frog.

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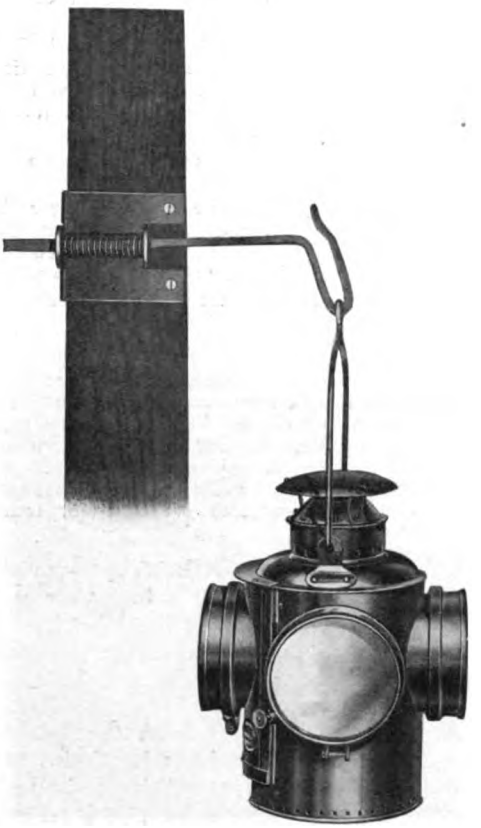
L

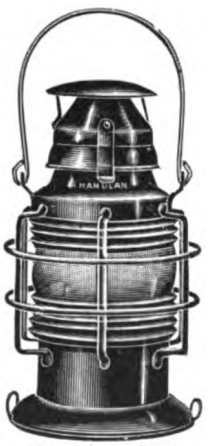
LADDER TRACK. The diagonal lead track of a yard from which two or more adjacent side tracks are turned out, the diagonal leads of double end sidings being located usually at each end of the yard, leading off from the main track. See Lead Track.

LAMP, CROSSING GATE. A signal lamp designed to be hung on a gate protecting a highway



Adlake Crossing Gate Lamp with Hanger, in Open Position
The Adams & Westlake Co.

grade crossing to indicate the position of the gate at night as a warning to highway traffic against railway train movements. This lamp is designed to show lights in the directions of the highway only, and is preferably hung on a hinged spring hook which moves with and absorbs the shocks incident to the opening and closing of the gate and keeps the lamp always in an upright position.



Crossing Gate Lamp
The Handlan-Buck Manufacturing Co.

LATCH, SWITCH STAND. A device for catching and holding the lever of a switch stand in position.

LEAD, ACTUAL. That portion of a turnout measured along the gage line of the main track from the actual point of the switch to the actual point of the frog.

LEAD, CURVED. The actual or theoretical part of a turnout, measured along the outside gage line from the heel of the switch to the toe of the frog.

LEAD, MAIN. The distance measured along the parent track from the actual point of switch to the actual point of frog of a turnout.

LEAD, PRACTICAL. See Lead, Actual.

LEAD RAIL. One of a line of rails in a turnout laid between and connecting the heel of the switch and the toe of the frog.

LEAD, THEORETICAL. The distance from the theoretical point of a uniform turnout curve to the theoretical point of frog, measured along the line of main track. See Turnout. Also Switch.

LEAD TRACK. A track leading off a parent track and built especially for the insertion of turnouts with a view to minimizing the number of switches in main or busy tracks. See Turnout.

LEAVING END (Of Rail). That end of a rail in a track carrying one-way traffic which comes last in contact with the wheels of rolling stock.

LEG OF FROG. One of two rails converging to form the tongue or point of a frog. The term is also applied to all four track rails of a crossing frog, in which case they are known as inside and outside legs. See Frog. Also Frog, Crossing.

LENGTH OF FROG. The distance between the toe end and the heel of a frog, measured along the gage line of the running rails.

LENGTH OF SWITCH. The distance between the actual point and the heel, measured along the theoretical gage lines, usually 11 ft., 16 ft. 6 in. or 22 ft., these lengths cutting economically from standard 33-ft. rails. See Switch Point Rail.

LENS (Switch Lamp). A device made of glass, having spheroidal surfaces and set in a switch lamp frame for the purpose of controlling the conveyance of rays of light from the lamp upon a fixed path.

These lenses are usually from five to six inches in circumference and are molded of colored glass

Lenses for Switch Lamps
The Corning Glass Works
(See Page 673)

usually with convex outer surfaces and serrated inside surfaces so formed as to properly refract the light from the lamp. A reverse lens has the serrations on a concave front surface while the rear surface is convex and smooth, and a plane convex glass covers the front surface. An advantage of this lens is the inaccessibility of the serrated face to condensation from either side. See Roundel (Signal Section).

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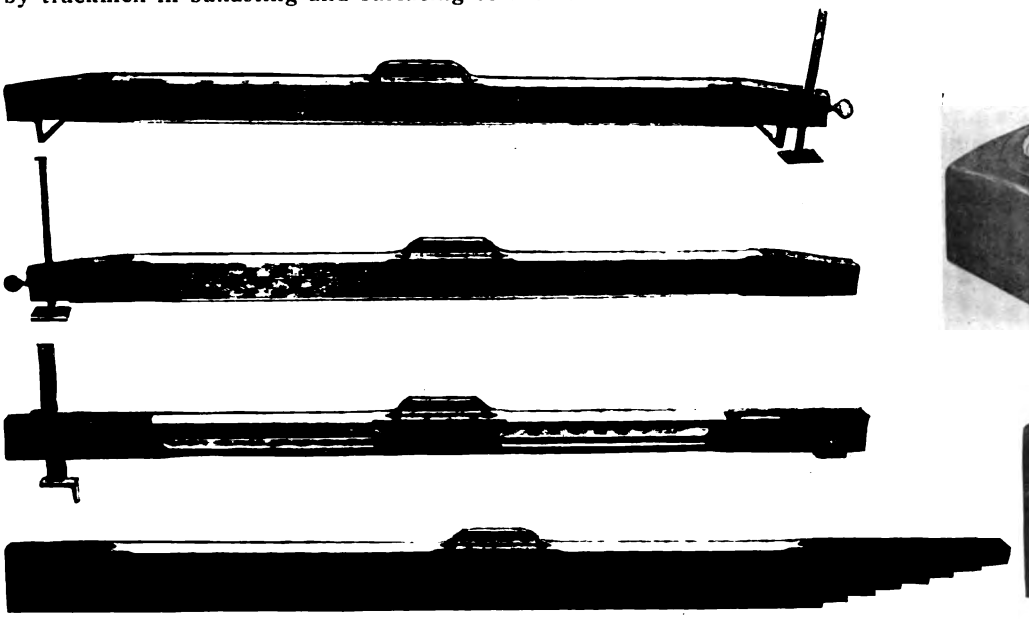
LENS COLORS, SWITCH LAMP. The colored glass of which lenses are made to produce specified switch light indications.

Most switch lamp lenses are made and colored according to Railway Signal Association specifications. The glass is of a certain degree of clearness and the coloring of a specified intensity, in order to transmit a maximum of light. Such lenses are called high transmission lenses. The colors commonly used are red, yellow, green, white, blue and purple. Red is the usual danger or stop signal. Green is used for caution or slow, by companies which use white for clear or proceed. The tendency to eliminate white as a signal color is based on the danger of mistaking lights of missing lenses for clear signals. When yellow is used for caution, green indicates clear or proceed. Blue or purple is used for repair track protection. See Roundels (Signal Section).

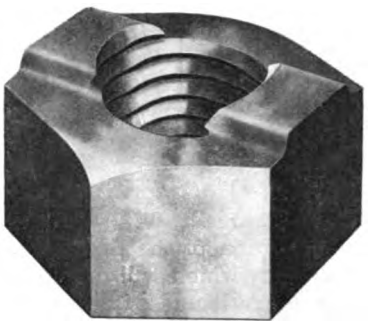
LEVEL BOARD. A leveling contrivance used by trackmen in ballasting and surfacing to ascertain the relative elevations of the opposite rails of a track. This device is commonly made of a dressed white pine or maple board, about 1½ in. thick, 6 in. wide and 5½ ft. long, having a spirit level countersunk in the top edge at the center or one near each end, and a handle or hand-hold usually at the center. The end of the level board is sometimes made with steps or offsets of depths equal to the approved elevation for the outer rails of curves of different degrees. Another type has a wood or steel graduated scale on one end, the scale being moved in a vertical groove or slot and held in position by a thumb screw and bolt on the side of the board. The bottom edge of the level board is sometimes protected with two strips of metal extending from the ends half way to the center.



No. 1 Combination Level and Gage
No. 2 Track Level
No. 3 Track Level
No. 4 Step Level Board

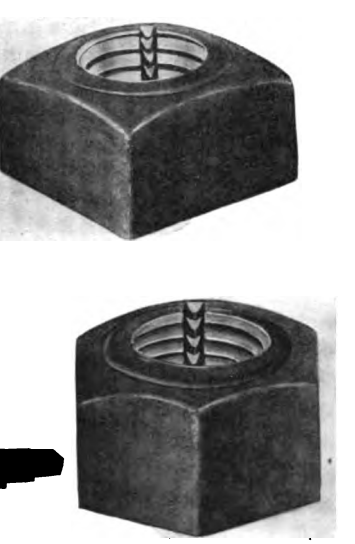
LINE SIDE (Of Track). The side to which ties are lined and from which lining and gaging is done, usually the north side of east and west tracks and the east side of north and south tracks.

LOCK NUT. A nut which locks and holds itself on a bolt automatically and can be removed and reapplied readily.

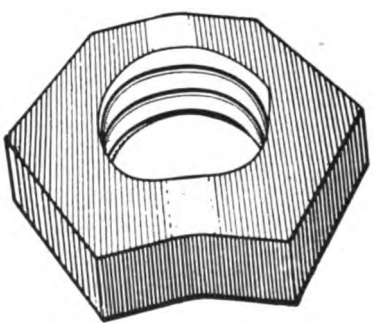


Hot Pressed Lock Nuts
The Grip Nut Co.
(See Page 701)

The lock nut is used largely to lock common nuts on the bolt and for this purpose is put on after the common nut. As a measure of economy such lock nuts are made thinner than the common nuts which they protect. When a lock nut is forced against another nut, which is thereby pressed against the web of the rail or other work, the thread grip of the protected nut is relaxed and the lock nut bears the stress. An advantage of using a lock nut in place of, not with common nut, is economy in the bolt and nut metal and in labor of application and maintenance. A lock nut cannot be made efficient on a bolt of inferior



Hot Pressed Lock Nuts
Patterson Lock Nut Manufacturing Co.



Hexagon Lock Nut
The Jones Positive Lock Nut Co.

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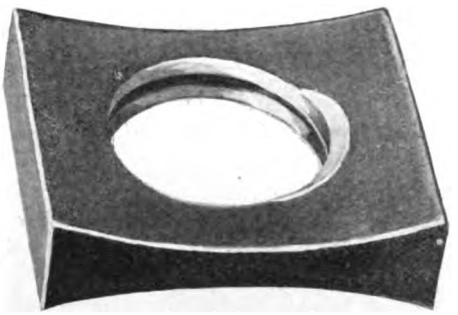


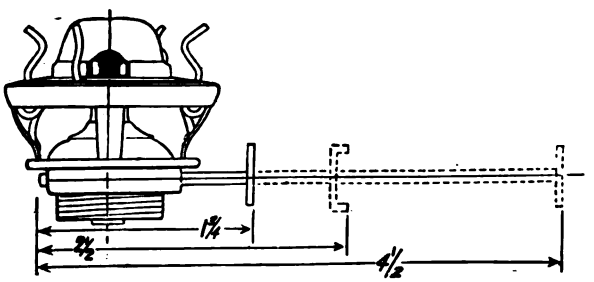
Lock Nut
Boss Nut Co.
(See Page 661)

material and with undersized threads. The manner of locking is usually by distortion of the threads of the nut, by introducing a catch which will not back off or a concave surface of resilient metal which allows slight distortion when the nut is pressed home, or by cutting edges on the nut which bite into the metal of the work and resist dislodgement, etc. Some lock nuts are designed for use only in combination with special bolts made to receive the locking device. Lock nuts are specially applicable to bolts used where there is danger of losing the nuts, especially where vibration introduces an element of danger, as in frogs, crossings and special track work, moving parts of machines such as engines, pumps, motor cars and dump cars, conveying machines, etc. See Lock Nut.

LOCK WASHER. A type of washer acting to prevent a nut from turning. See Lock Nut.

LONG POINT RAIL. The longer of the two pieces of rail which are planed, shaped and riveted to form the point of a frog. See Frog.

LONG-TIME BURNER (Switch Lamp). A metal wick-holding and flame-regulating device designed to perfect the combustion of the oil, reduce the heat produced in the lamp, prevent incrustation of the wick, intensify the light and reduce the frequency of attention necessary for a switch lamp. The ordinary burner requires daily care. The long-time burner, with suitable wick, oil and fount should



Handlan Long Time Switch Lamp Burner
The Handlan-Buck Manufacturing Co.

not need more than two visits per week from the attendant.

It holds a cylindrical, soft cored wick in a central tube which flares at the top so as to spread the flame, while perforations in the metal beneath and around the flame holder help to regulate the ventilation and combustion. Long-time burners are used generally in lamps not conveniently situated for daily care, as at outlying switches on branch lines, on ladder switch stands, etc.

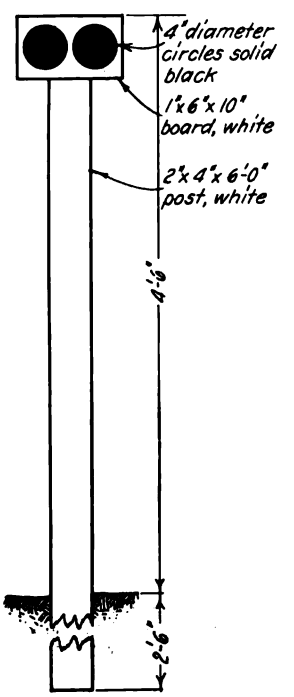
LUG. See Switch Rod Clip.

M

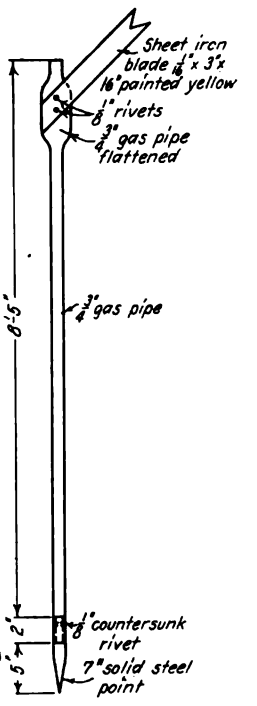
MAIN TRACK. The principal line or lines of a railway. The running track of a railway whereon the movement of trains is controlled by time table, train order or block signal.

MARKER, SNOW PLOW. A post or sign indicating by its location the proximity of an obstruction which makes necessary the raising of snow flangers or the closing of snow plow wings.

This marker is set on the engineman's side of the



Snow Plow Marker Used on the Great Northern



Snow Plow Marker Used on the Michigan Central

track about 8 ft. from the nearest rail and 20 ft. to 50 ft. in the direction of approaching trains from the obstruction which it indicates. It is usually a temporary marker removed during the summer season although some railways erect permanent signs. It may consist of a wood or metal post with a small board or steel plate of distinctive shape or with a simple symbol such as a "V", a cross, a star or two circles painted in colors which render it readily distinguishable on a snow-covered roadway, such as black or yellow on a white background.

A common type of removable snow plow marker consists of a sharp pointed ¾ in. gas pipe 8 ft. long flattened at a point about 8 in. from the top and there drilled for two rivets which secure flatwise to the shaft one end of a strip of sheet iron 2 in. wide and 15 in. long, which is inclined 45 deg. from the axis of the shaft set to face the traffic and point away from the track and painted yellow. The pointed shaft is easily forced into the ground and readily freezes in position.

A type of permanent snow plow marker is a 4 in. by 4 in. post 4 ft. high above the ground painted white and bearing near its top a rectangular board 6 in. deep and 12 in. wide on which are painted

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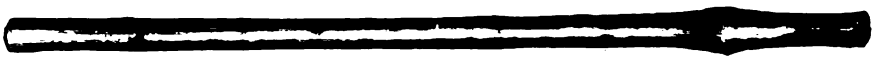
side by side two solid black circles 4 in. in diameter or dots on a white background.

MAUL, SPIKE. A two-faced steel hammer weighing from 6 lb. to 12 lb., used for driving cut steel track spikes, etc.

Pennsylvania Spike Maul
(See Pages 706, 829 and 832)

Pittsburgh Spike Maul
(See Pages 706, 829 and 832)



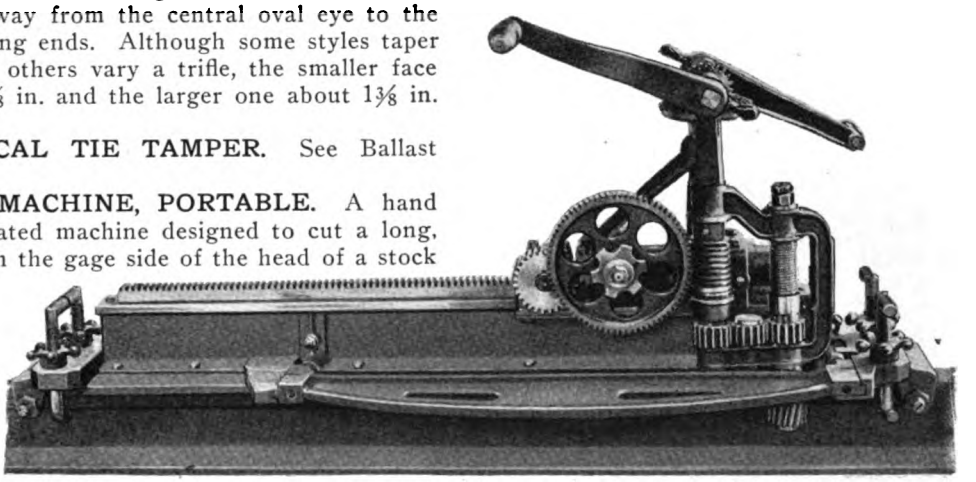
Maul Handle

Standard Spike Maul
(See Pages 706, 829 and 832)

It consists commonly of a double tapered steel head about 12 in. long, placed crosswise at the end of a wooden handle 3 ft. long. The steel head tapers slightly each way from the central oval eye to the opposite striking ends. Although some styles taper symmetrically, others vary a trifle, the smaller face being about ⅞ in. and the larger one about 1⅜ in. diameter.

MECHANICAL TIE TAMPER. See Ballast Tamper.

MILLING MACHINE, PORTABLE. A hand or power-operated machine designed to cut a long, thin piece from the gage side of the head of a stock rail in the track to provide an accurate housing for the switch point. This method eliminates the necessity for kinking or chipping the stock rails at split switches to recess the switch point. By means of a system of set screws, guides and gages, the operator can adjust and fasten the machine on any standard rail and control the depth of cut made by the milling cutter which is geared to a horizontal ratchet and cuts smoothly from the switch point toward the frog, completing a housing in about 20 minutes. See Switch.



Hilliard Portable Milling Machine
Hilliard Portable Milling Machine Company

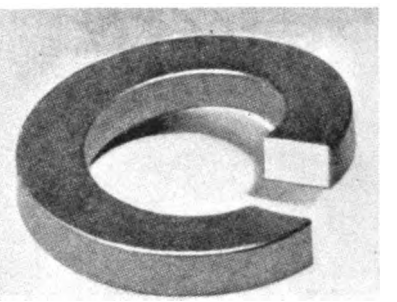
N

NUT LOCK. A spring washer or other device designed to fit on a bolt ahead of the nut, to prevent the nut of a bolt from turning or loosening, to prevent the battering of the threads by wear against the edge of the bolt hole in the web of the rail, and to automatically take up any slack due to stretching or wear and to keep the bolt tight.

The nut lock should not be confused with the lock nut, which is a different device. There are various devices for locking a nut in position, the most common being the spring washer. Some springs extend to two bolts, locking both nuts; some lock by extensions, straight or bent; some are U-shaped, some are plates and some are bent rods. With few exceptions nut locks are made of spring steel.

The use of nut locks on all track bolts including those in rail joints, frogs, switches and railway crossings is accepted as good practice and is generally followed. Without a nut lock the joint bar of a rail joint tends to destroy the threads of a bolt which

Hipower Nut Lock
The National Lock Washer Co.
(See Page 755)



Reliance Lock Washer
The Reliance Manufacturing Co.
(See Page 787)

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chafe against the edges of the bolt hole. The maintenance of bolts in tight adjustment requires some such device as a spring washer because of the gradual elongation of bolts in service and the gradual wearing off of rough spots and scale from bearing surfaces on joint bars and rails. The spiral steel washer is the style most generally used in track work.

The A. R. E. A. specifications for a spiral spring nut lock are as follows:

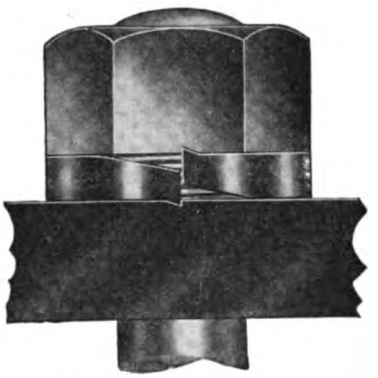
Material. Steel from which the nut locks are made must be of open-hearth steel, or other approved process, and shall conform to the following chemical analysis:

Phosphorus, not over 0.05 per cent.
Sulphur, not over 0.05 per cent.

Physical Properties and Tests. After the finished nut lock has been subjected for one hour to pressure sufficient to compress it flat and has been released, its reaction shall be not less than two-thirds its height or thickness of section, provided the thickness is less than the width of section. If the section is square, the reaction must be not less than one-half its thickness. If the height or thickness of section is more than the width, the reaction shall be not less than the width of the section.

With one end of the finished nut lock secured in a vise, and the opposite end twisted to 45 deg., there must be no sign of fracture. When further twisted until broken, the fracture must show a good quality of steel.

A sufficient number of tests shall be made to satisfy the inspector that the material meets the specifications in every respect.



Positive Lock Washer—Applied to a Nut
The Positive Lock Washer Co.

Workmanship and Finish. The dimensions and form of the nut lock shall conform to the drawings submitted to the manufacturer.

Nut locks shall be clean, without burrs or rough edges. The coil and cross section shall be uniform throughout.

The manufacturer is required to guarantee:

(1) That the steel was thoroughly annealed and permitted to assume its proper molecular structure before being made into nut locks.

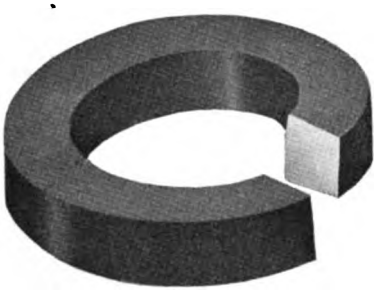
(2) That the subsequent heat treatment was scientifically accurate according to the best methods known, to secure uniformity of temper and the highest efficiency attainable.

Inspection. When required, the manufacturer shall furnish samples of nut locks from a preliminary lot before proceeding with the filling of the order, and give sufficient notice in advance of the date when they will be ready for inspection.

The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the mill and the manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy himself that the nut locks are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each separate heat treatment. Two pieces shall be selected for each test and if both meet the requirements of the specifications the lot will be selected and tested; if one of the test pieces fails a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected.



High Tension Nut Lock
(See Pages 707, 790, 829)

If after shipment, any nut locks are found to be defective due to material or manufacture, they may be rejected.

Marking and Shipping. When nut locks are shipped they shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size and number contained therein, and the name of the manufacturer.

NUT, SPRING BOLT. Either a plain or grooved nut used on spring bolts. The common form is the plain nut.

O

OIL FOUNT (Switch Lamp). The metal container placed in the switch lamp, from which illuminating oil is drawn by capillary attraction through the wick, to be burned. The founts in general use are of seamless pressed steel with capacities of 16 oz. to 31 oz. of oil. Seams are objectionable in oil founts on account of the likelihood of the heat generated by the flame melting the solder, especially in windy or humid weather when ventilation may be retarded.

P

PARENT TRACK. A track from which a turnout is constructed. A main track is the parent track as regards a passing siding. A ladder track is the parent track as regards the yard tracks turning out from it.

PIPE (Rail). A cone-shaped shrinkage space in the central top part of a steel ingot, due to the relatively rapid cooling of the outside portion of the metal near the walls, contraction while cooling progressing gradually toward the middle.

The pipe may be a definite and only slightly irregular cone in the top metal which is discarded, or it

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may extend brokenly down to the central and lower portions of the ingot. Rails made of metal with this dangerous defect, which is generally accompanied by segregation, are liable to more or less sudden failure. In rolling metal with such shrinkage spaces, which are always in the center if the ingot cools in an upright position, the sides of the pipe are pressed together in the web of the rail and appear as a fold of two separate dark surfaces, smooth and unwelded. To minimize pipes steel has been cast in wide ingots set in sand molds with the large end up, with slow feeding, liquid compression and the use of a sinking head. See Rail Failure.

PIPE THIMBLE (Switch). A metal tube designed to fit around the heel block bolt, and to pass through the web of the switch rail, and between the joint bar and the heel block; acting as a separator between these parts to permit free hinge motion at the heel of the switch. See Heel Block (Switch).

PIPED RAIL. A rail in which the sides of the shrinkage cavity formed in the ingot are closely pressed together in the web of the rail but not welded.

Piped rails usually fail completely, the pipes being commonly if not always accompanied by segregation and occasionally extending into the head of the rail. Piped rails are dangerous and cannot always be detected before failure. When the rail fails under load it usually breaks across the section irregularly and often in several pieces. The pipe is then readily detected by the dark smooth interior surfaces of the broken web. The trackman's only safe method is to promptly remove all rails showing black seams or a tendency toward sagging of the metal in the head of the rail.

PLATE, CLIP. A special plate used to fasten the flange of a frog to the base plate.

PLATE, HEEL. A tie plate usually 17 in. to 19 in. long used on a tie under the rail joint at the heel of a split switch, the plate supporting the stock rail as well as the adjacent turnout rail.

PLATE, RISER. A switch plate with a portion of its upper surface raised with a view to supporting the sliding switch point rail at the proper elevation relative to the stock rail. The riser plates of a set may be uniform or graduated according to the top planing of the switch rail.

PLATE, TURNOUT. A long tie plate designed to support a stock rail and the adjacent turnout rail on a tie between the heel of a switch and the point where the divergence of the turnout from the main track is sufficient to permit the use of separate tie plates for each rail. The longest turnout plate is placed where the adjacent edges of the rail bases are about 4 in. apart, the number of plates in a set depending on the angle of divergence.

POINT, HALF INCH (Frog). The point at which the divergence of the lines of the frog angle equals half an inch. Because it is practicable to manufacture rail frogs with blunt points ½ in. wide this width has been adopted by manufacturers as the origin from which shop measurements are made, while manganese cast frog points being about ⅝ in. wide, the ½-in. point is marked and used in shop measurements and plans. See Point of Frog, Theoretical. Also Actual Point of Frog.

POINT BLOCK. The filler block located at the frog point of a built-up frog. See Filler Block.

POINT NOTCH (Frog). A slight offset cut into the planed side of the long point rail of a turnout frog to receive the blunt cut end of the short point rail. This notch in the joint of the converging rails which form the frog point is a sturdier and more practicable construction than a joint made on a straight line.

POINT OF FROG, THEORETICAL. The apex of the angle formed by the converging gage lines of the running rails of a frog.

The theoretical point is the origin to which calculations in the theory and manufacture of frogs is referred.

POINT OF SWITCH, THEORETICAL. The point at which the turnout originates and from which measurements to the theoretical point of frog are made. See Actual Point of Switch.

POINT RAIL. See Switch Point Rail.

POINT SEPARATOR BLOCK. The filler block located at the frog point of a built-up frog.

POST, DIVISION. A post set on a railway right-of-way to mark the dividing line between two operating divisions for the information and guidance of employees.

A division post generally consists of a wood, metal, concrete or stone post or monument from 8 ft. to 10 ft. long, square in section and set approximately 3 ft. to 3 ft. 6 in. in the ground at a distance of from 8 ft. to 11 ft. from the nearest running rail. The inscriptions usually consist of the names of the two divisions painted in white on black backgrounds, each on a separate face or side of the post, which should be set cornerwise so that both names are visible from the track side.

POST, END OR CORNER. A post located at the end of a line or section of fence. The strength, the foundations and the bracing of end posts are of special importance because the stability of the intermediate panels depends to some extent on the rigidity of the end posts, especially when the longitudinal members of the fence are in tension, as in wire fences. While fencing usually surrounds an enclosure, therefore having corners instead of ends, many single barrier lines are built, such as wing fences to stock guards and party fences between adjacent rights-of-way where end posts are neces-

National Concrete Corner or End Fence Post
The National Concrete Machinery Co.
(See Page 754)

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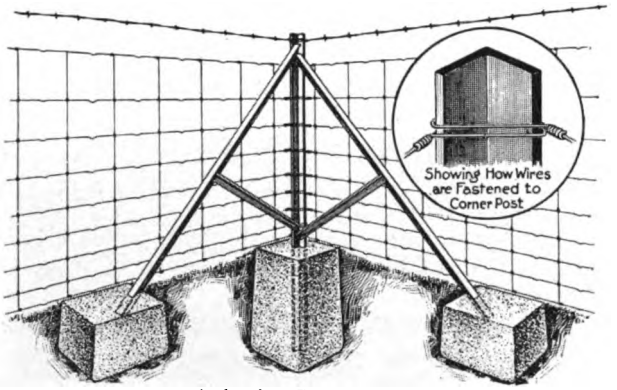
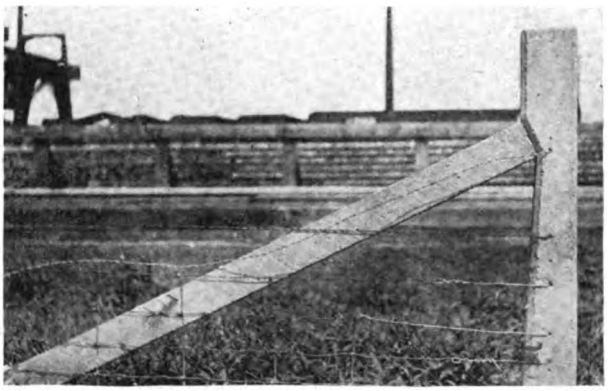
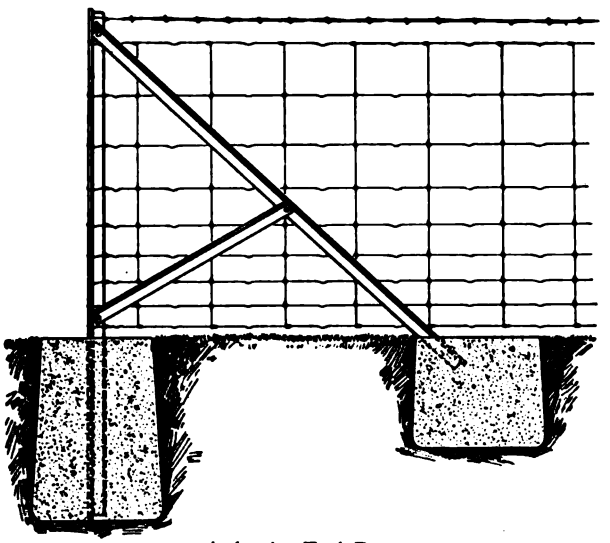
sary and where because of the stress of the fence on one side and lack of protection on the other, the end posts selected must be stronger, longer, more deeply set and more stoutly braced than line posts. It is common practice where an end post is exposed to wagon traffic, to protect it by planting an inclined



Ankorite Corner Post
The Calumet Steel Co.



Concrete Corner Post and Brace



Ankorite End Post
The Calumet Steel Co.

section of rail or a short guard post on the traffic side. The bracing on the fence side frequently involves two half-length fence panels though this arrangement is not universal.

POST, MILE. A post or a combination of a sign and a post placed on a railway right-of-way as an indicator of the number of miles from some designated terminus or termini. It is commonly used as a basis for the location of tracks, buildings or structures on maps and other records.

The ordinary mile post is a wooden, metal, concrete or stone post or monument from 8 ft. to 10 ft. long, set approximately 3 ft. or 3 ft. 6 in. in the ground at a distance of about 8 ft. from the nearest rail on fills and not over 11 ft. to 12 ft. in other cases, and on the engineman's side of the roadway. The post is usually painted white, the face of the sign varying in width from 10 in. to 12 in. with numbers and usually the first letter of the name of the terminus painted on each face.

POST, RING. A marker in the form of a post placed along a railway track for the guidance of trainmen on trains approaching highway crossings, yards, etc., where regulations require the locomotive bell to be rung. It is usually made identical with a whistle post except that the letter R is substituted for the letter W. See Post, Whistle.

POST, WHISTLE. A marker placed on the engineman's side of a track and in advance of a public road crossing, an unprotected railway crossing, a station, a yard, etc., to indicate that the train is nearing a point where the law or other rules require that the locomotive whistle be blown as a warning of its approach. It is usually a wooden, metal or less frequently a reinforced concrete post about 10 ft. long and 12 in. wide, set 3 ft. to 3 ft. 6 in. in the ground from 2,000 ft. to 4,000 ft. in advance of the point protected and about 10 ft. from the center of the track, the face of the sign being at right angles to the line of the track. The post is generally painted white with a black letter W painted on the face although these colors are sometimes reversed. Other types are small signs mounted on posts, or posts of distinctive shapes and colors with or without lettering, the contour of the sign, the design upon its surface or a particular color indicating its purpose. Whistle posts are sometimes placed in the center of the space between the shoulder of the roadbed and the right of way boundary line, the position depending on the relative positions of other signs which must be displayed, so that none may be obscured from the line of sight of enginemen. See Post, Ring.

R

RADIUS, ACTUAL. The radius of a curve extending between the heel of a standard switch and the toe of a standard frog as a substitute for the theoretical radius. The length of the actual radius is somewhat shorter than the theoretical radius, the alteration being designed to make the lead of such length that rails may be cut economically to fit.

RADIUS, THEORETICAL. The radius of a curve which is tangent to the main track at the theoretical point of switch and tangent to the turnout track at the theoretical point of frog.

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RAIL (Track). A rolled steel shape, commonly a T-section, designed to be laid end to end in two parallel lines on cross ties to form a track for railway rolling stock. Some railways, notably in Great Britain, use a double-headed section called a bull-head rail which is held upright in castings called rail chairs which are fastened on each tie.

Rails were first rolled of iron in England about 1830. They were followed by steel-capped wrought-iron rails, and later by Bessemer steel rail, the manufacture of which began in the United States about 1866. More recently the open hearth process of steel manufacture has come into general use and since 1908 its tonnage has exceeded that of Bessemer steel which has steadily declined until in 1918 approximately 80 per cent of the rails rolled in the United States were of open hearth steel. This change has resulted largely from the scarcity of ores which it is possible to treat successfully by the Bessemer process.

The desirable elements present in rail steel are iron, carbon, manganese and silicon, while the impurities are phosphorus, sulphur, gases and slag. Carbon is the most important element next to iron, for the tensile strength and elasticity of the metal increase in direct ratio to the carbon content up to about one per cent, while the ductility decreases.

The amount of carbon in Bessemer steel rails weighing from 70 lb. to 85 lb. per yard inclusive is commonly limited to 0.4 per cent to 0.5 per cent carbon, and for sections weighing from 85 lb. to 100 lb. per yard inclusive, from 0.45 per cent to 0.55 per cent. Owing to the greater uniformity of open hearth steel, rails made by that process of sections weighing from 70 lb. to 85 lb. per yard inclusive, commonly have a specified carbon content of 0.53 per cent to 0.66 per cent carbon. Brittle steel is an indication of too much carbon while soft steel indicates the reverse.

Manganese is a deoxidizer and tends to impart to the metal toughness and high resistance to abrasion. Bessemer steel rails commonly contain from 0.8 per cent to 1.1 per cent manganese, while specifications for open hearth steel rails permit 0.6 per cent to 0.9 per cent manganese.

Silicon is present in all iron and steel. Its affinity for oxygen makes it especially useful in removing the gases not eliminated by the manganese. A silicon content of not less than 0.1 per cent is specified for all open hearth and Bessemer steel rails.

Phosphorus is the most injurious impurity in rail steel because it reduces the power of the metal to resist impact, making it cold-short or brittle when cooled. A phosphorus content not to exceed 0.1 per cent is allowed in Bessemer rails, while the maximum percentage in open hearth rails is 0.4 per cent.

Sulphur tends to form sulphide films between the steel fibres which result in making the steel red-short, rendering it liable to crack or crumble during the process of rolling. The presence of any percentage of sulphur in rail steel is therefore objectionable and is to be avoided if possible.

Slag is the molten cinder or residue which carries the impurities that are tapped away from the molten metal. Great care is taken to prevent particles of slag from remaining in the steel which is poured into the ingot mold.

The wearing qualities of a rail depend quite as much on the rolling as on the soundness of the steel in the ingot. It is the practice to first shear off and discard the defective metal, sometimes as much as 20 to 30 per cent, from the top of the ingot to eliminate imperfections which commonly collect there and render the steel in that portion of the ingot unreliable. Gradual reduction of the remainder of the ingot by many rollings, with slow speeds in the last five or six passes tends to produce well kneaded, fine-grained steel. The number of passes to which an ingot is subjected to reduce it to the finished section varies from 18 to 30 according to the practice in the different steel mills, these passes being divided about equally between the blooming mill and the rolling mill. Railway men generally favor the larger number of passes with a corresponding decrease in reduction of section per pass. After the last pass, the rail is hot-sawed to proper length and stamped, then run through a cambering machine which bends the head convexly so that its thicker section, which shrinks more than the base, tends to straighten in cooling. It is also turned on the hot beds, if necessary to help straighten it, and after cooling it is cold-straightened in a gagging press, after which the bolt holes are drilled and the rail is ready to be loaded for shipment.

The suitability of rail steel, as indicated by its compliance with the specifications, is determined by chemical analysis and by actual tests of the soundness and ductility of samples of the finished rail of each heat in the mill as the manufacture proceeds. Chemical analyses are made from sample borings from the ingot, tested for carbon, manganese, silicon, phosphorus and sulphur, for each heat of open hearth steel; and for day and night turns of Bessemer steel with daily carbon determinations for each heat before the rail is shipped. Physical tests are made by means of a drop hammer on sample sections of finished rail four to six feet long, selected from the upper end of the top rail of the ingot. The test section is commonly subjected to three blows of the tup falling from heights of 16, 17 and 18 ft. Those which do not break are nicked and broken to determine whether the metal has any such interior defects as seams, laminations, cavities or interposed foreign matter "made visible." The purchaser commonly obtains promptly from his inspector copies of all records of tests, chemical and physical, which are valuable for later reference if the character of the rails is called in question at any time. In addition to the above a special from of inspection is applied to a considerable proportion of the rails rolled in this country whereby inspectors observe closely and report in detail results of each step in the manufacture of the steel and the rolling of the rails of each heat, for the information of the final inspector who accepts or rejects the rail and for later record.

The rails made during the first few years of American practice were less than 20 ft. long, but they have gradually increased in length as the lengths of cars available for transportation have increased until 33 ft. is now the standard length. For several years considerable tonnages of 60 ft. rails were rolled and laid; but the difficulties of transportation and of the expansion and contraction of these long rails in the track due to changes in temperature finally led to

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the abandoning of this length as standard, although long rails, usually of this length are still used where it is desired to avoid or reduce the number of rail joints, as at highway grade crossings, bridge ends, etc. As a rule the mills charge a premium for rails longer than 33 ft. The standard contracts commonly contain provisions for the acceptance of not to exceed ten per cent of rails less than 33 ft. long, the short lengths varying by one foot from 32 ft. to 25 ft. These short rails are marked with green paint on the ends. These rails are ordinarily used about yards, frequently in switch leads. Not to exceed five per cent of No. 2 rails, which by reason of bends, kinks or surface imperfections cannot be classified as No. 1 rails may be accepted as seconds, being distinguished by two punch marks on the side of the web and by white painted ends.

The height and width of the base of a rail are usually almost equal, although the present tendency is toward slightly higher and narrower sections. Thus a 60-lb. rail is approximately 4 in. wide across the base and 4-in. high while a 100-lb. rail is about 5½ in. wide and 6-in. high.

The section of the rail is intimately related to the processes of manufacture, as well as to service conditions. It is desirable to have a section with the metal in the head and the web well balanced in order to obtain a rail that will straighten uniformly in cooling without setting up excessive cooling stresses. The base is preferably made thick enough to fill out easily and to allow the entire section to be rolled at relatively low temperatures, permitting the maximum amount of rolling to be done, especially on the head of the rail. Other considerations entering into the design of the rail section are the destribution of the metal with a view to obtaining the greatest stiffness and strength, a maximum depth of joint bar, a neutral axis at the center line of bolt holes, and adequate width of base in proportion to the height, fishing angles of 13 to 15 deg. and a head with the top corners shaped with regard to the contours of standard wheel flanges.

Though various railways have their individual rail sections, rolled with a view to meeting their peculiar service demands, the general tendency is toward a relatively thick base, a narrow head and large web angles, as well as toward heavier sections for the various services. To lessen the friction of the wheels and permit free slippage rails of a special section with a narrow head are sometimes laid on the insides of sharp curves. The most widely used American rail designs are the A. S. C. E. sections, developed by the American Society of Civil Engineers in 1893 and later adopted by a majority of the railways; and the A. R. A. sections "A" and "B" which were approved in 1915 and which now have to a great extent superseded the A. S. C. E. sections. Both of these A. R. A. sections are designed with relatively thick bases with a view to minimizing the base failures, which were becoming increasingly numerous in the A. S. C. E. sections. The high "A" section is designed to afford the stiffness needed in high speed main line tracks, while the lower, larger headed "B" section is intended for slow, heavy freight traffic.

Main line tracks are now commonly laid with rails weighing from 85 lb. to 105 lb. per yd., although a few roads have recently adopted as standard sections weighing up to 130 lb. and 135 lb. per yard. Secondary and branch line tracks are usually supplied with 60 lb. to 80 lb. rail released from main tracks. The average weight of the rail in all main line tracks in the United States at present is about about 85 to 90 lb.

The wear of rail depends on the excellence of track maintenance as well as on the ton mileage, the wheel loads and the speeds of trains passing over it. The points of greatest wear are generally at the joints, which depend largely on the maintenance of the track bolts for efficiency. The super-elevation of the outer rail of curves which influences rail wear is determined and maintained with due regard for train speeds and grades. Weather conditions also directly affect the condition of the rail, which is carefully watched in summer to prevent creeping and sun kinks, and properly shimmed in winter to maintain a reasonable track surface when steel is most sensitive to shock and most likely to break.

If rails does not wear evenly on the crown, there is usually some fault in the laying or in subsequent track conditions. Rail that wears on the inside of the head should be rolled in to a true bearing with the prescribed inward cant of the head. Rail rolling is a frequent necessity on sharp curves where wheel flanges crowd the rail heads outward. Flange-worn rails are frequently removed from the outsides of curves, turned and replaced on the inside with the unworn side of the head on the gage side of the track. Rails that are becoming surface bent are sometimes relaid with new joints, which tend to straighten them and so add to their service life. In resurfacing track, the joints of surface-bent rails are commonly raised a fraction of an inch above the general track level, with a view to straightening the rail.

It is usual to keep at least one serviceable main track rail and one rail joint complete on a rail rest at each mile post to replace worn or broken rails in case of emergency. If the rails in the track show more than average wear, two rails are preferably placed on the rail rest for winter and stocks of spare rails at division headquarters are similarly increased.

The following specifications for carbon steel rails have been adopted by the A. R. E. A., with added informatory notes on manufacture:

Specifications for Carbon Steel Rails

Inspection

1. **Access to Works.** Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the rails have been made and loaded in accordance with the terms of the specifications.

2. **Place for Tests.** All tests and inspections shall be made at the place of manufacturer prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Material

3. The material shall be steel made by the Bessemer or open-hearth process, as provided by the contract.

Chemical Requirements

4. The chemical composition of the steel, determined as prescribed in section 6, shall be within the following limits:

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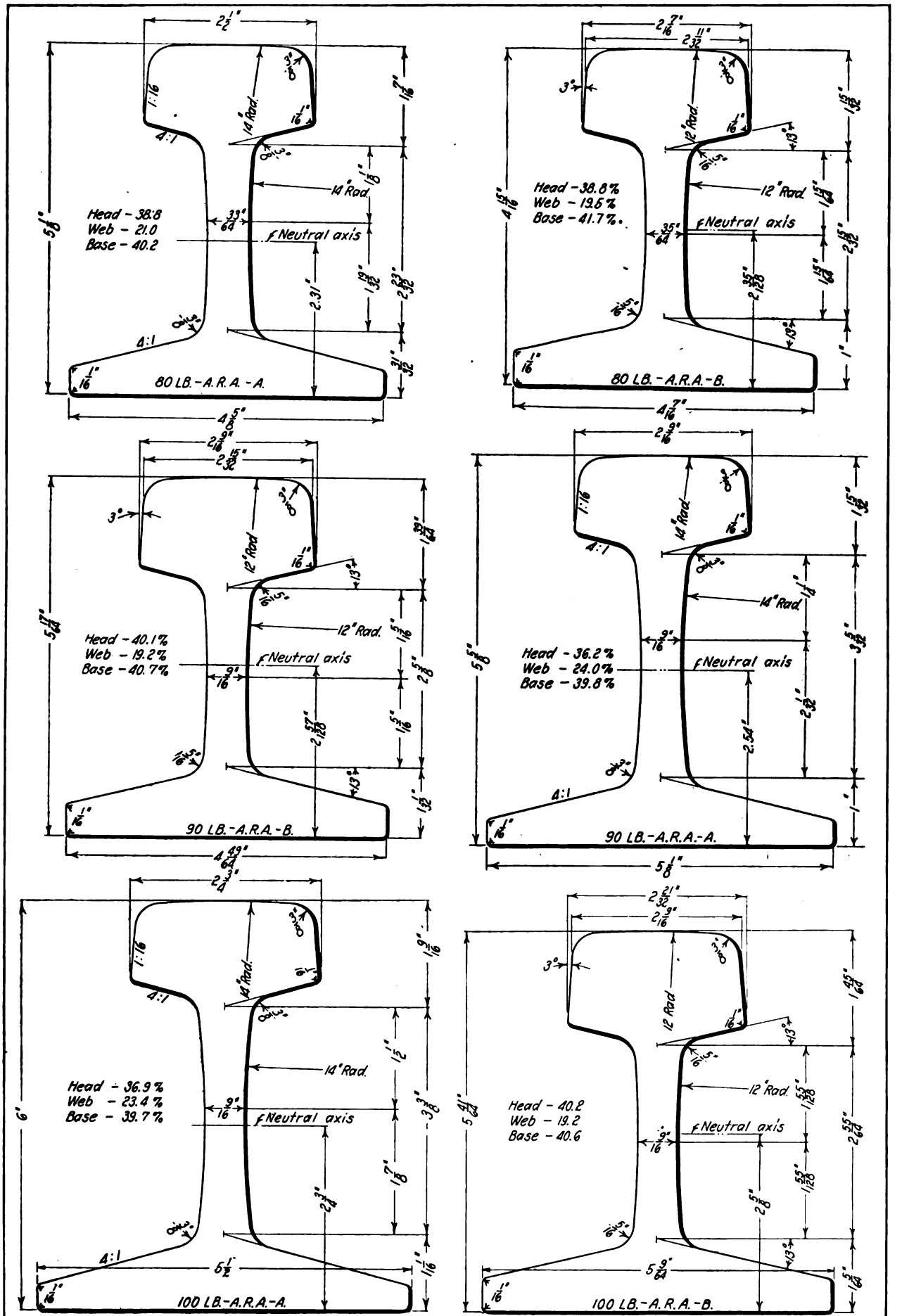

A. R. A. Standard Rail Sections—Half Size

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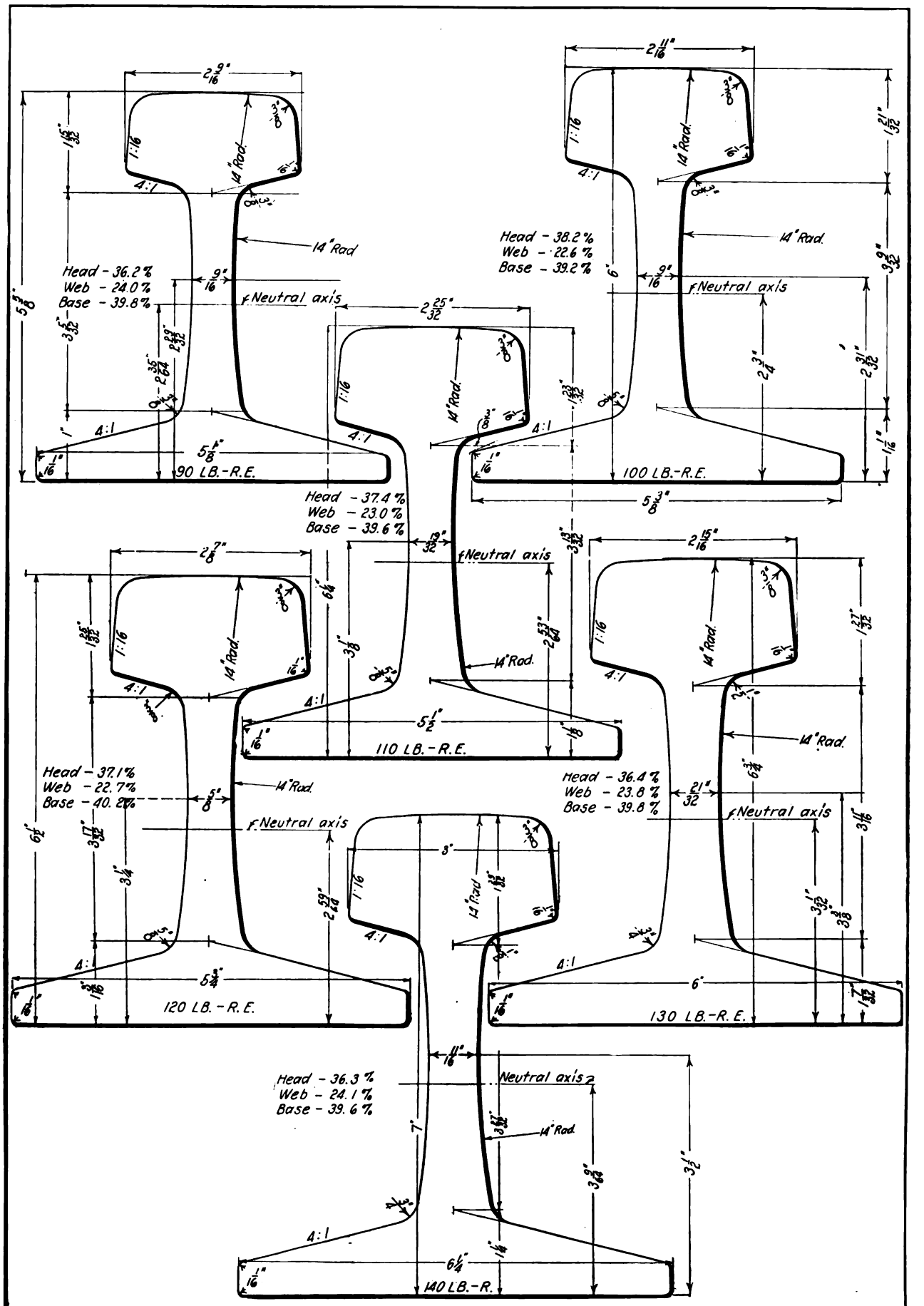

A. R. E. A. Standard Rail Sections—Half Size

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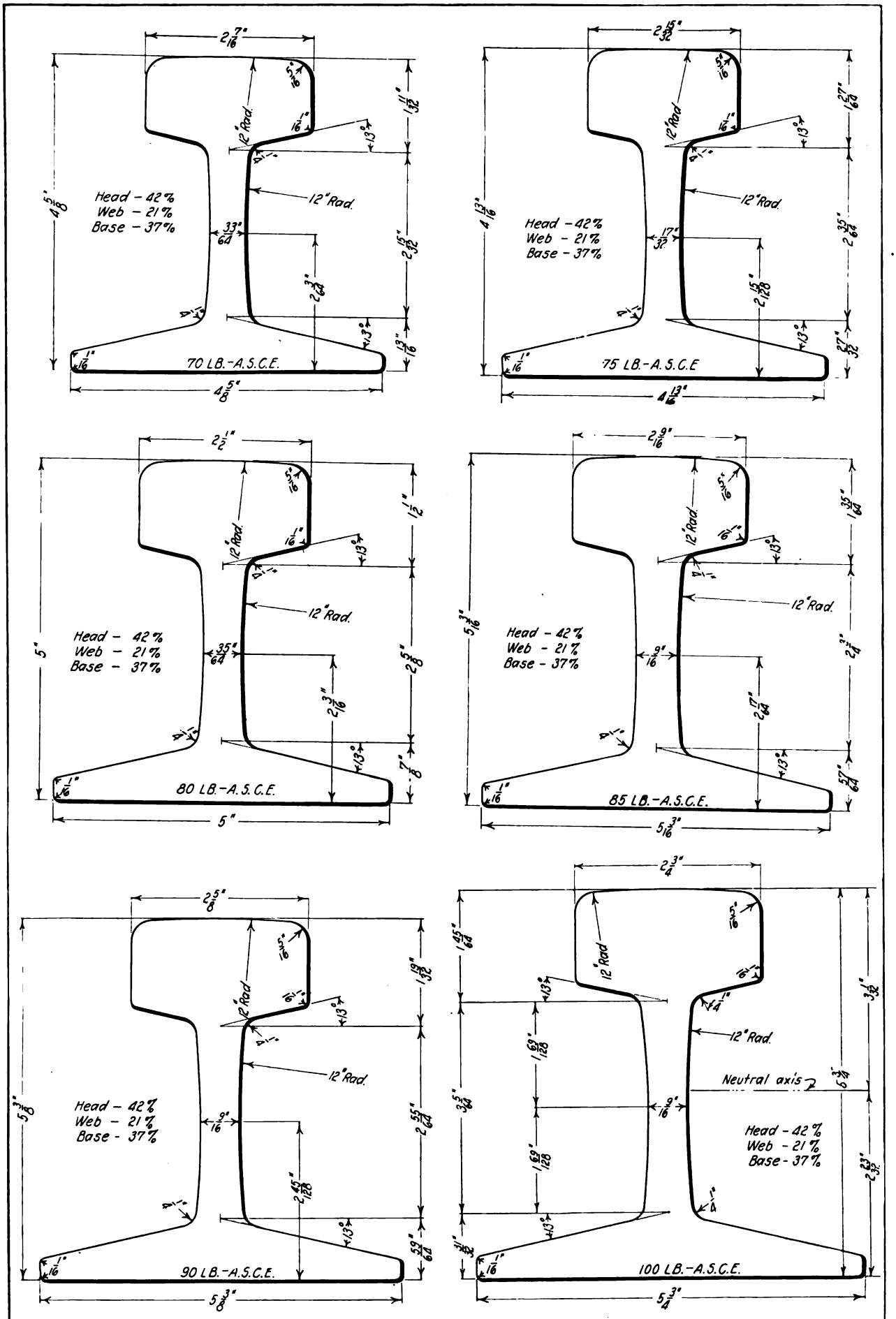

A. S. C. E. Standard Rail Sections—Half Size

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Constituent Elements	Bessemer Process (Limits per cent), Weight in lb., per yd.		Open-Hearth Process (Limits per cent) Weight in lb., per yard		
	70-84	85 and over	70-84	85-110	111 & over
Carbon	0.40 to 0.50	0.45 to 0.55	0.53 to $0.68	0.62 to 0.77	0.67 to 0.82
Phosphorus, not to exceed	0.10	0.10	0.04	0.04	0.04
Manganese	0.80 to 1.10	0.80 to 1.10	0.60 to 0.90	0.60 to 0.90	0.60 to 0.90
Silicon, not less than	0.10	0.10	0.10	0.10	0.10

5. **Average Carbon.** It is desired that the percentage of carbon in an entire order of rails shall average as high as the mean percentage between the upper and lower limits specified.

6. **Analyses.** In order to ascertain whether the chemical composition is in accordance with the requirements, analyses shall be furnished as follows:

(A) *Bessemer Process.* The manufacturer shall furnish to the inspector daily, carbon determination for each heat before the rails are shipped, and two chemical analyses every 24 hours representing the average of the elements, carbon, manganese, silicon, phosphorus and sulphur contained in the steel, one for each day and night turn, respectively. These analyses shall be made on drillings taken from the ladle test ingot not less than ⅛ in. beneath the surface.

(B) *Open-Hearth Process.* (a) Finished Rail Analysis. On each heat the manufacturer shall make an analysis of the elements, carbon, manganese, phosphorus, sulphur and silicon. A copy of the results shall be given to the inspector. Drillings for these analyses shall be taken longitudinally of the rail with a ½ in. drill, close to an upper corner of the head from any one of the three drop test pieces representing the top of the ingot, or from pieces cut adjacent to any one of these three drop test pieces.

(b) *Ladle Analyses.* For the information of the inspector the manufacturer shall furnish a chemical analysis of the elements, carbon, manganese, silicon, phosphorus and sulphur, for each heat. These analyses shall be made on drillings taken from the ladle test ingots not less than ⅛ in. beneath the surface.

(C) *Check Analysis.* On request of the inspector, the manufacturer shall furnish a portion of the ladle test ingot for the Bessemer process and a portion of the drillings from the finished rail for the open-hearth process for check analysis. When made a part of the contract, the manufacturer shall furnish the necessary facilities at the mill for the purchaser's representative to make the check analysis.

(D) When the analyses for carbon by the mill chemists and by the railroad chemist do not agree, a tolerance of two points below the minimum and two points above the maximum will be allowed to cover such variation before condemnation.

Physical Requirements

7. **Physical Qualities.** Tests shall be made to determine:

(a) Ductility or toughness as opposed to brittleness;
(b) Soundness.

8. **Method of Testing.** The physical qualities shall be determined by:

(a) The drop test, or
(b) The quick bend test, if made a part of the contract.

9. **Drop Testing Machine.** The drop testing machine used shall be the standard of the American Railway Engineering Association, the essential points of which are:

(a) The tup shall weigh 2,000 lb., and have a striking face with a radius of 5 in.

(b) The anvil block shall weigh 20,000 lb., and be supported on springs.

(c) The supports for the test pieces shall be part of, and firmly secured to, the anvil; their bearing surfaces shall have a radius of 5 in.

(d) The spacing of the supports between centers shall be; 3 feet for rails weighing 110 lb. or less per yard; 4 feet for rails weighing from 111 to 140 lb. per yard, inclusive.

10. **Machine for Quick Bend Test.** The quick bend test shall be made with a hydraulic press of not less than 350 tons capacity, some of the details of which are as follows:

(a) The foundations for the supports of the test specimens shall be adequate to sustain rigidly the total load applied by the press.

(b) The supports shall be solid flat bearing surfaces with vertical faces 48 in. apart, with the inner edges rounded to a ⅛ in. radius.

(c) The head of the ram shall have a bearing face with a radius of 5 in.

(d) The speed of the ram shall approximate 13 ft. per minute when allowed free travel.

(e) A hydraulic indicator shall be connected with the press so that the pressure on the head of the ram is registered by the pen arm on a vertical scale, and the distance rotated by the cylinder shall be proportional to the travel of the ram head.

11. **Test Specimens.** (a) Test specimens shall be one or two feet longer than the span between supports in the testing machine.

(b) Test specimens shall be cut from the crop of the top rail of the ingot, and marked on the center line of the top surface of the head with gage marks one inch apart for three inches each side of the center of the specimen, for measuring the ductility of the metal.

(c) Where it is necessary to test rails lower than the first rail, the bottom of the first rail, in lieu of the top of the second rail, and the bottom of the second rail, in lieu of the top of the third rail, will be accepted, if preferred by the manufacturer.

(d) The temperature of the test specimens shall be between 60 and 100 deg. F.

(e) Unless otherwise instructed by the purchaser, the test specimens shall be tested with the heads in tensions with the center punch marks midway between the supports.

12. **Height of Drop.** The test piece shall be subjected to impact of the tup falling free from the following heights:

For 70 to 79 lb. rail, incl.....16 ft.
For 80 to 90 lb. rail, incl.....17 ft.
For 91 to 110 lb. rail, incl.....18 ft.
For 111 to 140 lb. rail, incl.....20 ft.

13. **Elongation.** Under these impacts the rail under one or more blows shall show at least 8 per cent elongation for one inch of the six-inch scale, marked as described in Section 11 (b).

14. **Exhausted Ductility Test.** A sufficient number of blows shall be given to determine the complete elongation of the test piece of at least every fifth heat of Bessemer steel, and of one out of every three test pieces of a heat of open-hearth steel.

15. **Permanent Set.** For each specimen, a record shall be made of the permanent set, measured on a 3 ft. chord, after each blow under the drop test.

16. **Test to Destruction.** The test pieces which do not break under the first or subsequent blows shall be nicked and broken, to determine whether the interior metal is sound. The words "interior defect," used below, shall be interpreted to mean seams, laminations, cavities or interposed foreign matter made visible by the destruction tests, the saws or the drills.

17. **Bessemer Process Physical Tests.** One piece shall be tested from each heat of Bessemer steel.

(a) If the test piece shows the required elongation (Section 13), all the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(b) If the test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the top rails from that heat shall be rejected.

(c) A second test shall then be made of a test piece selected by the inspector from the top end of any second rail of the same heat, preferably of the same ingot. If the test piece shows the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(d) If the test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the second rails from that heat shall be rejected.

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(e) A third test shall then be made of a test piece selected by the inspector from the top end of any third rail of the same heat, preferably of the same ingot. If the test piece shows the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(f) If the test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the remainder of the rails from that heat shall be rejected.

18. **Open-Hearth Process Physical Tests.** Test pieces shall be selected from the second, middle and last full ingot of each open hearth heat.

(a) If all of these test pieces show the required elongation (Section 13), all of the rails of the heat shall be accepted, provided that no test piece when broken shows interior defect.

(b) If any test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the top rails from that heat shall be rejected.

(c) Second tests shall then be made from three test pieces selected by the inspector from the top end of any second rails of the same heat, preferably of the same ingots. If all these test pieces show the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that no test piece when broken shows interior defect.

(d) If any test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the second rails of the heat shall be rejected.

(e) Third tests shall then be made from three test pieces selected by the inspector from the top end of any third rails of the same heat, preferably of the same ingots. If all these test pieces show the required elongation (Section 13), all of the remainder of the rails of the heat shall be accepted, provided that no test piece, when broken, shows interior defect.

(f) If any test piece does not show the required elongation (Section 13), or if when broken shows interior defect, all of the remainder of the rails from the heat shall be rejected.

19. **No. 1 Rails.** No. 1 rails shall be free from injurious defects and flaws of all kinds.

20. **No. 2 Rails.** Rails which vary from the specifications in a manner which does not impair their soundness and strength will be accepted as No. 2 rails. The rails to be so accepted are as follows:

(a) Rails arriving at the straightening process with sharp kinks or greater camber than that indicated by a middle ordinate of 4 in. in 33 ft. for the thick base sections, and 5 in. for the thin base sections.

(b) Rails which do not contain surface imperfections in such number or of such character as will, in the judgment of the inspector, render them unfit for recognized No. 2 uses.

Rails accepted as No. 2 rails shall have the ends painted white, and shall have two prick punch marks on the side of the web near the heat number, near the end of the rail, so placed as not to be covered by the joint bars.

No. 2 rails to the extent of 5 per cent of the whole order will be accepted.

Details of Manufacture

21. **Quality of Manufacture.** The entire process of manufacture shall be in accordance with the best current state of the art.

22. **Record of Manufacture.** When made a part of the contract, the manufacturer shall furnish the inspector with a carbon copy of open hearth or Bessemer charge sheets; records of melting, tapping, ladle and teeming conditions; soaking pit charge sheets; rolling mill operation; rail weight sheets; hot bed and straightening records, wherever such sheets or records are in regular use by the manufacturer.

23. **Bled Ingots.** Bled ingots, from the center of which the liquid steel has been permitted to escape, shall not be used.

24. **Discard.** There shall be sheared from the end of the bloom, formed from the top of the ingot, sufficient metal to secure sound rails.

25. **Lengths.** The standard length of rails shall be 33 ft., at a temperature of 60 deg. Fahrenheit. Ten per cent of the entire order will be accepted in shorter lengths varying by 1 ft. from 32 to 25 ft. A variation of ¼ in. from the specified lengths will be allowed, excepting that for 15 per cent of the order a variation of ⅜ in. from the specified lengths will be allowed. No. 1 rails less than 33 ft. shall be painted green on both ends.

26. **Stool Cutting.** Care should be taken in teeming the ingots to prevent cutting out of the cast iron of the stools of ingot molds by the falling stream of hot metal from the ladle, and thus avoid a frequent cause of carbon streaks found in the finished rail.

27. **Mold Spattering.** Spattering the interior sides of the molds in pricking the heats or melts and teeming the ingots must be avoided as much as possible.

28. **Stopper Defects.** Excessive use of material thrown into the teeming ladle to set the stopper must be avoided.

29. **Aluminum.** The steel must be made to set quiet by the chemical composition in the molds without the addition of aluminum, either in the ladle or molds.

30. **Time for Ingot Setting.** Time must be allowed for the tops of the ingots to set without spraying with water.

31. **Ingots Vertical.** Ingots shall be kept in a vertical position on the ingot cars and in the reheating furnaces until their heat is equalized ready to be rolled.

32. **Section.** The section of rails shall conform as accurately as possible to the template furnished by the railroad company. A variation in height of 1/64 in. less or 1/32 in. greater than the specified height and 1/16 in. in width of flange will be permitted; but no variation shall be allowed in the dimensions affecting the fit of the joint bars.

33. **Weight.** The weight of the rails specified in the order shall be maintained as nearly as possible, after complying with the preceding section. A variation of ½ per cent from the calculated weight of section, as applied to the entire order, will be allowed.

34. **Hot Bed Work and Straightening.** (a) Care must be taken in cambering the rails and with the hot-bed work so that rails will cool with a small but uniform sweep, and therefore gagging under the presses will be reduced to a minimum.

(b) Rails while on the cooling beds shall be protected from snow, water and excessive gusts of cold wind.

(c) When delivered to the straightening presses rails shall not vary in any direction from a straight line throughout their entire length more than 4 in. for the RE and RA thick base sections, and not more than 5 in. for ASCE sections.

(d) The supports for rails in the straightening presses shall have flat surfaces and be out of wind, and shall be spaced not less than 42 in. The application of the gag shall be central between supports and the overhang of either end of the rail during straightening should be supported.

(e) Rails heard to snap while being straightened shall be at once rejected.

35. **Drilling.** Circular holes for joint bolts shall be drilled to conform to the drawings and dimensions furnished by the railroad company. A variation of 1/32 in. in the size and location of bolt holes will be allowed.

36. **Finishing.** (a) All rails shall be smooth at the heads, straight in line and surface, and without any twists, waves or kinks. They shall be sawed square at the ends, a variation of not more than 1/32 in. being allowed; and burrs shall be carefully removed.

(b) Rails improperly drilled or straightened, or from which the burrs have not been removed, shall be rejected, but may be accepted after being properly finished.

(c) When any finished rail shows interior defects at either end or in any drilled hole, the entire rail shall be rejected.

37. **Branding.** Rails shall be branded for identification in the following manner:

(a) The name of the manufacturer, the month and year of manufacture, and the weight and type of section of rail shall be rolled in raised letters and figures

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on one side of the web. This type shall be marked by letters which signify the name by which it is known, as for example:

Sections of American Society of Civil Engineers.....A. S. C. E.
Sections of American Railroad Association.....R. A.-A., R. A.-B.
Sections of American Railway Engineering Association.....R. E.

(b) The heat and ingot number as rolled and letter indicating the portion of the ingot from which the rail was made shall be plainly stamped on the web of each rail where it will not be covered by the joint bars. The top rails shall be lettered A, and the succeeding ones B, C, D, etc., consecutively; but in case of a top discard of from 20 to 35 per cent, the letter A will be omitted, the top rail becoming B. If the top discard be greater than 35 per cent, the letter B shall be omitted, the top rail becoming C.

(c) Open-hearth rails shall be branded or stamped O-H in addition to other marks.

(d) All markings of rails shall be done so effectively that the marks may be read as long as the rails are in service.

38. **Separate Classes.** All classes of rails shall be kept separate from each other.

39. **Loading.** Rails shall be carefully handled and loaded in such manner as not to injure them. When a part of the contract, all first quality rails of each heat shall be kept together in loading.

40. **Payment.** Rails accepted will be paid for according to actual weight.

Matters Subject to Contract

Clause 3 —Steel may be Bessemer or open-hearth.
Clause 6c—Check analysis.
Facilities for analyses at the mill.
Clause 8 —The quick bend test.
Clause 22 —Record of manufacture.
Clause 40 —Loading.
Keeping rails of each heat together.

Notes on Manufacture Added as Information
(To be attached to the specification)

Note A:
The selection of the ores, scrap, molten metal, fluxes and other furnace additions; regulation and quality of the port gases; condition of the slag, furnace bottom and lining; temperature of the bath, and time for refinement of each melt of steel require especial attention so that the molten steel when tapped will be refined and deoxidized.

Note B:
The steel must be well deoxidized and the waste products eliminated before the ingots are teemed, and thus prevent minute portions of the deoxidation products from becoming entrained in the setting metal. Time is required for the deoxidation products and impurities to rise after the steel is tapped into the ladle.

Note C:
Loose material and dirt should be removed from the ladle before tapping is commenced to prevent impurities from being incorporated in the molten metal. The ladle lining should be well set before tapping.

Attention should also be given to the proper coating of the ingot molds, and care should be taken to remove dirt or loose material from the tops of the ingot buggies before setting up the molds.

Note D:
The ingots should be stripped as soon as the metal caps over on top; weighed and charged promptly into the soaking pits, and thus avoid cooling of the interior metal. This checks the shrinkage of the steel, which may be large, depending upon the volume, chemical composition and temperature of the ingot at the time it is charged. The interior shrinkage can be confined to 0.05 to 0.1 per cent per cu. ft. of the metal, so that it is eliminated in the usual discard of the bloom, and helps to prevent piped rails due to cold ingots.

Note E:
The ingots should be uniformly heated in the soaking pits and the port gases properly regulated to prevent overheating, and with protection from direct impingement against the vertical faces of the ingots. The large hot ingots should be soaked at least two hours before blooming.

Note F:
Blooming the ingots and rolling the blooms into finished rails should all be done when the ranges of temperature for the ingots, blooms and rails are suitable for the metal to be cambered and then cooled so that the transformations and recalescence will be complete for the desired steel.

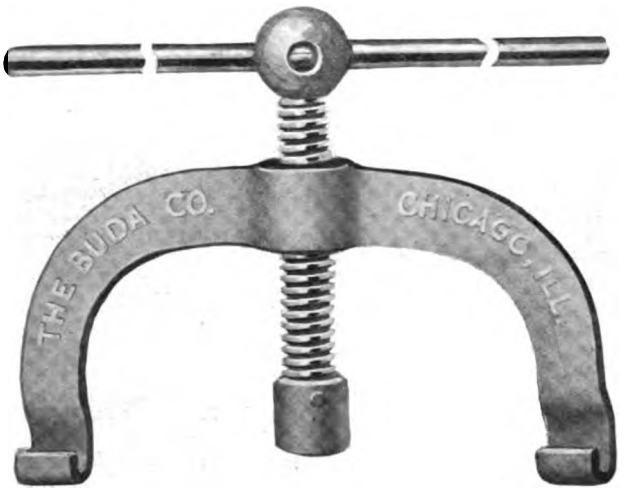
Note G:
The hot rails from the saws and on the hot-beds should be spaced to allow the recalescence of the head to follow that of the base without being locked or blocked by adjacent rails on either side.

Note H:
The effect of straightening may be materially reduced for the heavier and stiffer sections by spacing the supports in the press at 60-in. centers. Several mills have made the necessary changes with beneficial results.

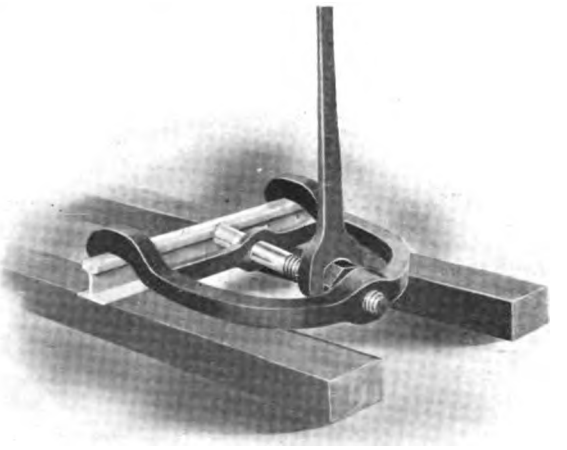
Care should be taken to see that the supports of the presses are not worn hollow, and the gags used have rounded corners, and are in good condition.

RAIL BEARING. That portion of the tie or other support which is located beneath the base of the rail and which sustains direct pressure from it.

RAIL BENDER. A tool or a shop machine for bending rails to fit curves in track, turnouts, turntable circles, frogs, crossings, etc. The portable rail bender is generally supplied to trackmen to curve running rails, stock rails, etc., on the line, the tool weighing from 100 to 200 lb. A common type of



Jim Crow Rail Bender
The Buda Co.



Jim Crow Rail Bender with Cross Bar
The Buda Co.

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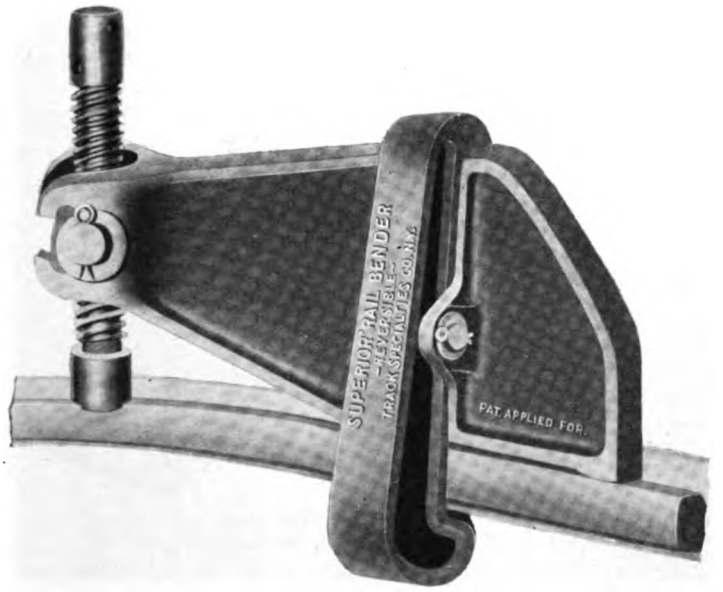
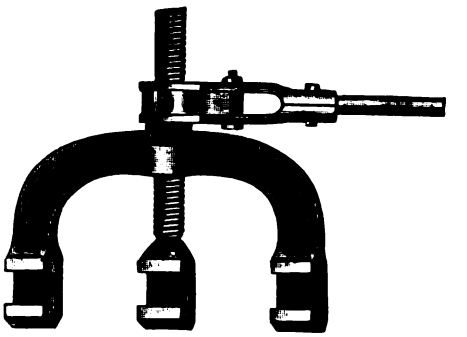
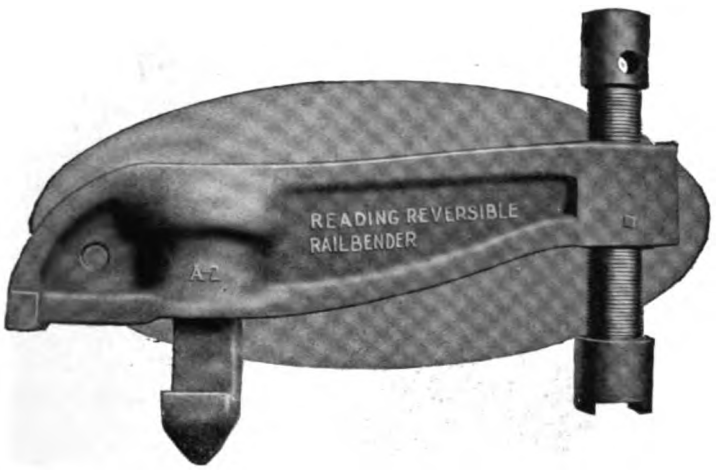


Superior Reversible Rail Bender
The Track Specialties Co.

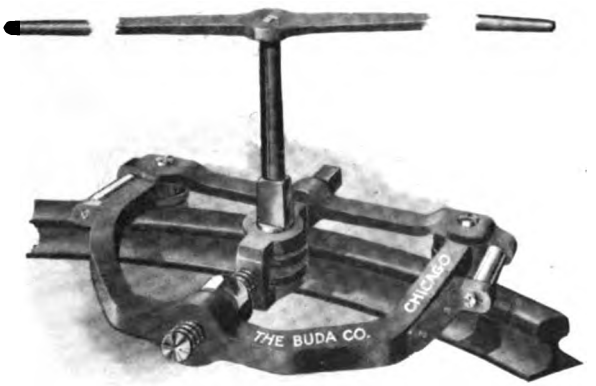
Vaughn Rail Bender
The M. W. Supply Co.



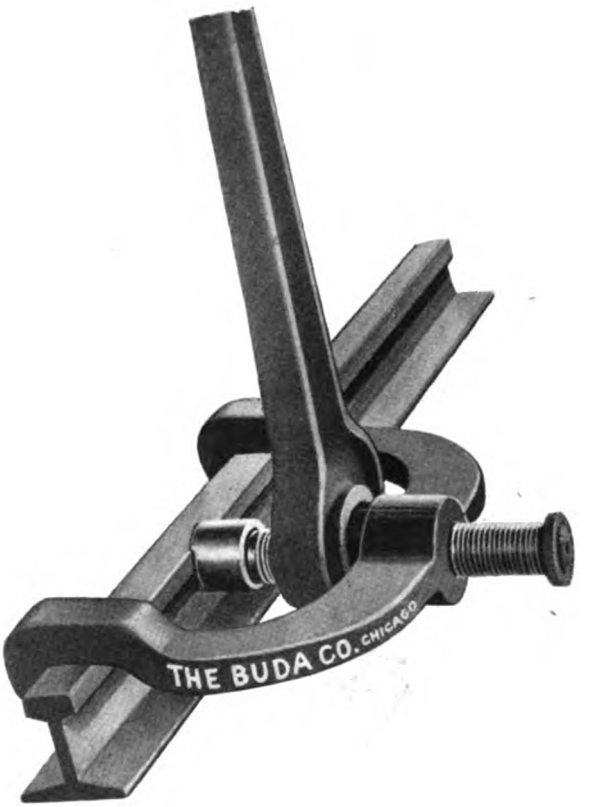
Double Acting Ratchet Type Rail Bender
George H. Carey



Reading Reversible Rail Bender
The Reading Specialties Co.
(See Page 787)



Roller Rail Bender
The Buda Co.



Jim Crow Rail Bender
The Buda Co.

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portable rail bender consists of a steel U or A-frame holding a central pressure screw bolt parallel with and midway between its arms which are crooked at the ends to hook over and outside the head of the rail to hold it while pressure is applied by the screw bolt, which is turned by means of a long-handled bar on a fixed nut inside the frame, or by a lever working in an eccentric bearing, and passed through the head of the U-frame which acts as the fulcrum. The contact end of the screw bolt rests in the socket of the fixed nut which is placed against the ball of the rail, while on the opposite end of the bolt is a square capstan-head by which the bolt is turned forward to bend the rail. A steel cross-arm sometimes placed just above the shoulders of the hooked ends of the frame is used to brace the arms and act as a support and guide for the bolt.

Another type of portable rail bender consists of a steel A-frame with hooked arms and a ratchet lever pressure bar fastened to the head of the frame extending midway between the hooked arms. A steel cross-bar acts as a brace and guide for the pressure bar, which is operated by a lever moving in a plane vertical to the rail.

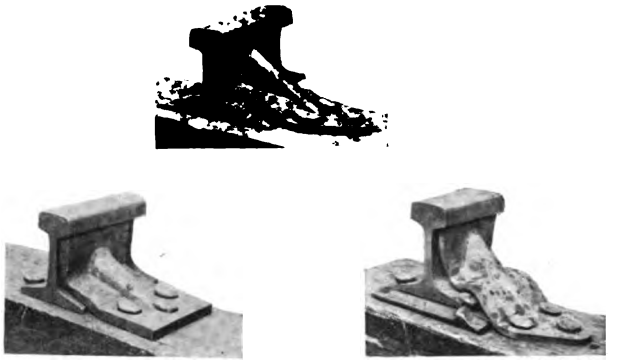
A third and more readily portable type is the two-piece rail-end bender, consisting of a steel shape combining a body, a hook and a lever arm in one casting. It is designed so that the body will rest snugly against the ball and web of the rail when the hook, located about the middle of the frame, engages the opposite side of the ball of the rail. The lever arm, arching away from the frame, carries a threaded, capstan-headed pressure screw bolt, moving in a grooved and threaded steel cap designed to be screwed forward by means of a thread through a hole in the capstan head. This device is used especially to bend running rails from end to end without removing them from service

A shop machine bender weighing about 400 lb., designed to curve rails uniformly throughout their length, has a U-shaped frame with grooved rollers on the ends of the arms which may be fitted to the outside of the head of the rail head, so that when it is turned by a lever or special wrench the machine travels along and bends the rail between the rollers. This type of bender is sometimes used in maintenance shops or at division headquarters. Care should be taken in using these powerful machines to avoid sharp cold bending, which tends to strain the rail fibre so that sudden expansion, contraction or deflection under subsequent concentrated loads may cause rail failures. Crooked, kinked and twisted rails which have been straightened by cold bending should be classified separately. See Rail, Relayer. (See Page 777).

RAIL BRACE. A metal casting made to fit against the side of a rail and to be spiked on a tie

Rail Brace
The Track Specialties Co.

3 Types of Rail Braces
The Track Specialties Co.



3 Types of Rail Braces
The Ajax Forge Co.
(See Page 629)

Morden Adjustable Rail Brace
The Morden Frog & Crossing Works
(See Page 752)

on the outside of the track to prevent the rail from inclining outward.

The brace has an upright face designed to fit against the web and the under side of the head of the rail, while the base furnished with spike holes rests flat on the tie and the diagonal rib connection gives stiffness against any outward thrust.

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RAIL BRAND. An identification mark, including the manufacturer's name, the month and year the rail was made, the weight per lineal yard of steel, the initials of the designing society or railway, the number of the heat, the portion of the ingot, and the process of manufacture.

These symbols are placed on the side of the web where they will not be covered by joint bars. The

Tennessee Coal & Iron Company

Sec. Nos. Old	Sec. Nos. New	Wt. Rail	Base Inches	Height Inches	Tread Inches
600	6040	60*	4 1/8	4 1/8	2 1/2
650	6540	65*	4 1/4	4 1/4	2 11/16
700	7040	70*	4 5/16	4 5/16	2 7/8
702	.....	70¶	4 1/4	4 11/16	2 1/2
750	7540	75*	4 1/2	4 1/2	2 11/16
752	7523	75	5	5	2 1/8
753	.....	75	5	4 3/4	2 1/2
754	.....	75	4 1/2	4 1/2	2 1/2
755	.....	75	4 1/4	4 1/2	2 7/8
800	8040	80*	5	5	2 1/2
850	8540	85*	5 1/4	5 1/4	2 5/8
854	.....	85	5	5 1/2	2 11/16
855	.....	85	5 1/4	5 1/4	2 11/16
900	9040	90*	5 1/16	5 1/2	2 5/8
901	9023	90	5 1/16	5 3/4	2 3/4
902	9020	90†	5 1/2	5 1/2	2 1/4
903	9030	90¶	4 1/2	5 1/2	2 1/2
904	.....	90	5 1/4	5 3/8	2 1/2
1500	.....	150	6	6	4 1/4

Carnegie Steel Company

Sec. Nos. Old	Sec. Nos. New	Wt. Rail	Base Inches	Height Inches	Tread Inches
60A	6040	60*	4 1/8	4 1/8	2 3/8
60H	6033	60	4 1/2	4 1/4	2 11/16
60K	.....	60	4 1/4	4 1/4	2 1/4
60M	.....	60	4 1/2	4 1/4	2 3/8
60O	.....	60	4 1/4	4 1/4	2 11/16
60P	.....	60	4 1/4	4	2 3/8
60R	.....	60	4 1/4	4 1/4	2 1/4
60ra	6020	60†	4	4 1/2	2 1/4
60rb	6030	60¶	3 11/16	4 1/4	2 3/8
61½N	.....	61½	4 1/4	4 1/4	2 1/4
63H	.....	63	4 1/4	4 1/4	2 3/8
63J	.....	63	4 1/4	4 1/4	2 3/8
65A	6540	65*	4 1/4	4 1/4	2 11/16
65G	.....	65	4 1/2	4 1/2	2 1/4
66B	.....	66	4 1/2	4 11/16	2 1/4
66K	.....	66	4 1/4	4 11/16	2 5/8
67F	.....	67	4 5/8	4 1/2	2 11/16
67H	6733	67	4 1/2	4 1/2	2 11/16
67L	.....	67	4 1/4	4 11/16	2 5/8
68Q	.....	68	4 1/2	4 1/2	2 11/16
68½P	.....	68½	4 3/8	4 1/2	2 11/16
70A	7040	70*	4 5/8	4 5/8	2 1/4
70B	.....	70	4 1/2	4 1/2	2 11/16
70D	.....	70	4 1/2	4 5/8	2 1/2
70H	7033	70	4 1/2	4 1/2	2 1/4
70ra	7020	70†	4 3/4	4 3/4	2 3/8
70rb	7030	70¶	4 1/4	4 1/4	2 3/8
71G	.....	71	4 3/4	4 3/4	2 1/4
72K	.....	72	4 3/4	4 3/4	2 1/2
72N	7250	72	4 3/4	4 3/4	2 3/8
75A	7540	75*	4 1/2	4 1/2	2 11/16
75B	7523	75	5	5	2 1/8
75C	.....	75	4 5/8	4 3/4	2 1/8
75D	7550	75	4 3/4	4 3/4	2 1/4
75E	.....	75	4 5/8	4 5/8	2 1/2
75K	7522	75	5	5	2 1/8
76L	.....	76	5	4 3/4	2 1/2
76M	.....	76	5	4 3/4	2 1/2
77½M	.....	77½	5	5	2 3/8
78N	.....	78	5	4 3/4	2 1/2
80A	8040	80*	5	5	2 1/2
80B	.....	80	5	5	2 1/2
80C	.....	80	5	5	2 3/8
80F	.....	80	5	5	2 1/2
80K	8022	80	5	5 1/8	2 1/2
80M	.....	80	5	5	2 1/2
80ra	8020	80†	4 5/8	5 1/8	2 1/2
80rb	8030	80¶	4 1/4	4 1/2	2 1/4
85A	8540	85*	5 1/4	5 1/4	2 1/4
85D	8550	85	5 1/4	5 1/4	2 1/2
85H	8533	85	5	5	2 1/4
85M	8553	85	5	5	2 1/2
85N	.....	85	5 1/4	5 1/4	2 1/2
85ps	8531	85	4 5/8	5 1/8	2 1/2
85R	8520	85	4 7/8	5 3/8	2 1/2
90A	9040	90*	5 3/8	5 3/8	2 3/8
90G	9034	90	5	5 3/8	2 3/8
90ra	9020	90†	5 1/4	5 1/8	2 1/4
90rb	9030	90¶	4 1/2	5 1/2	2 1/4
90S	9023	90	5 3/4	5 3/4	2 3/4
90X	9021	90	5 1/4	5 1/8	2 1/4
95A	9540	95*	5 1/4	5 1/4	2 11/16
100A	10040	100*	5 3/4	5 3/4	2 3/4
100H	.....	100	5 1/2	5 1/2	2 11/16
100K	10022	100	5 1/2	6	3
100N	10034	100	5 1/2	6	2 3/4
100pr	10032	100	5 3/8	5 1/4	2 1/2
100ps	10031	100	5	5 1/2	2 1/2
100ra	10020	100†	5 1/2	6	2 3/4
100rb	10030	100¶	5 1/4	5 1/2	2 1/2
110A	.....	110*	6 1/8	6 1/8	2 1/8

Pennsylvania Steel Company

Section No.	Wt. Rail	Base Inches	Height Inches	Tread Inches
6	60	4 1/8	4 1/8	2 3/8
244	60*	4 1/8	4 1/4	2 3/8
71	60‖	4 1/8	4 1/4	2 3/8
166	61	4 1/2	4 1/2	2 1/2
236	65*	4 1/4	4 1/2	2 11/16
117	65	4 1/2	5	2 1/8
145	66	4 1/2	4 1/2	2 1/4
112	66	4 1/2	4 1/2	2 1/2
2	67	4 1/2	4 1/2	2 3/8
62	68	4 1/2	4 1/2	2 1/2
68	68‖	4 1/2	4 1/2	2 1/2
113	70	4 1/8	4 1/2	2 1/8
57	70	4 1/2	4 1/2	2 1/2
46	70	4 1/2	4 1/2	2 1/2
97	70	4 1/2	4 1/2	2 1/2
237	70*	4 1/2	4 1/2	2 3/8
146	74	4 1/2	4 1/2	2 3/8
87	75	4 1/2	4 1/2	2 1/2
289	75	4 1/2	4 1/2	2 3/8
128	75	5	5	2 1/2
92	75	5	5	2 1/2
249	75	5	5	2 3/8
221	75	5	5	2 1/2
214	75*	4 11/16	4 11/16	2 11/16
248	75	4 1/2	4 1/2	2 1/2
216	76	5	4 1/2	2 1/2
98	78	5	4 1/2	2 11/16
76	79	4 1/2	4 1/2	2 1/2
220	80	5	5 1/2	2 1/2
171	80¶	4 1/4	4 11/16	2 1/2
114	80	5	4 11/16	2 1/2
78	80	5	5	2 1/2
169	80†	4 1/2	5 1/8	2 1/2
251	80*	5	5	2 1/2
119	83‖	5	5	2 1/2
67	85	5	5	2 1/2
156	85	4 1/2	5 1/4	2 1/2
261	85	5	5 1/2	2 1/2
172	85	4 1/2	5 1/2	2 11/16
67-A	85	4 1/2	5 1/2	2 1/2
235	85*	5 1/4	5 1/4	2 1/4
111	86	4 1/2	5 1/4	2 11/16
77	90	5	5	2 1/2
160	90	5	5 1/4	2 1/2
173	90	5 1/4	5 1/2	2 1/4
162	90¶	4 11/16	5 1/2	2 1/2
170	90†	5 1/2	5 1/2	2 1/4
245	90*	5 1/2	5 1/2	2 1/2
147	95	5 1/2	5 1/2	3
96	100	5 1/2	5 1/2	2 11/16
100	100	5 1/2	6	2 1/2
96-A	100	5	5 11/16	2 11/16
165	100	5 1/4	5 7/8	2 11/16
116	100	5 1/2	6	3
163	100†	5 1/2	6	2 1/4
247	100*	5 1/4	5 1/4	2 1/2
161	100¶	5 1/4	5 11/16	2 11/16
299	101	5 1/8	5 1/4	2 1/2
290	135	6	6 1/2	3 1/4

Bethlehem Steel Company

Section No.	Wt. Rail	Base Inches	Height Inches	Tread Inches
65A	65*	4 1/4	4 1/4	2 11/16
70A	70*	4 5/16	4 5/16	2 1/4
75C	75	5	4 11/16	2 5/8
75B	75	5	5	2 1/8
75A	75*	4 11/16	4 11/16	2 11/16
75D	75	5	5	2 1/8
80A	80*	5	5	2 1/4
85E	85	5	5 1/4	2 1/8
85D	85	4 5/8	5 1/8	2 1/2
85C	85	5.18	5.18	2.635
85B	85†	4 3/4	5 1/4	2 1/2
85A	85*	5 1/4	5 1/4	2 1/4
90E	90	5	5	2 1/4
90D	90†	5 1/4	5 1/4	2 1/4
90C	90¶	4 11/16	5 1/16	2 1/2
90B	90	5	5 1/2	2 1/2
90A	90*	5 1/4	5 1/2	2 1/2
95A	95*	5 1/4	5 1/4	2 1/4
100G	100¶	5 1/2	5 11/16	2 11/16
100F	100†	5 1/2	6	2 11/16
100E	100	5 3/4	5 3/4	2 1/2
100D	100	5	5 11/16	2 1/2
100C	100	5 1/2	6	2 1/2
100B	100	5 1/2	6	2 1/2
100A	100*	5 1/4	5 1/4	2 1/2
101H	101	5 1/2	5 1/4	2 1/4
105B	105	5 1/2	6	3
110B	110	5 1/2	6	2 1/8

*Indicates ASCE section rails.
†Indicates ARA series A section rails.
¶Indicates ARA series B section rails.

Illinois Steel Company

Sec. Nos. Old	Sec. Nos. New	Wt. Rail	Base Inches	Height Inches	Tread Inches
6001	6051	60	4 1/4	4 1/2	2 1/4
6007	.....	60	4 1/4	4 1/4	2 1/4
6008	.....	60	4 1/4	4 1/4	2 3/8
6009	.....	60	4 1/4	4 1/4	2 3/8
6012	.....	60	4 1/4	5 3/4	2
6013	.....	60	4 1/2	4 1/4	2 3/8
6014	.....	60	4 1/4	4 1/4	2 1/4
6015	6040	60*	4 1/4	4 1/4	2 3/8
6017	6033	60	4 11/16	4 1/4	2 11/16
6020	.....	60†	4	4 1/2	2 1/4
6030	.....	60¶	3 11/16	4 1/4	2 1/8
6101	.....	61	4 1/4	4 1/4	2 1/4
6301	.....	63	4 1/4	4 1/4	2 3/8
6501	.....	65	4 1/4	4 1/2	2 3/8
6503	.....	65	4 3/8	4 3/8	2 1/2
6504	.....	65	4 1/2	4 1/2	2 1/4
6506	.....	65	4 3/8	4 3/8	2 1/4
6507	6540	65*	4 1/4	4 1/4	2 11/16
6508	.....	65	4 3/8	4 11/16	2 1/4
6601	.....	66	4 1/4	4 11/16	2 11/16
6602	.....	66	4 1/2	4 11/16	2 1/4
6603	.....	66	4 1/4	4 11/16	2 3/8
6701	.....	67	4 1/2	4 1/2	2 11/16
6702	.....	67	4 3/8	4 1/2	2 11/16
6703	.....	67	4 1/2	4 1/2	2 1/2
6704	.....	67	4 1/2	4 1/2	2 11/16
6705	.....	67	4 1/2	4 3/8	2 11/16
6706	6733	67	4 1/2	4 1/2	2 11/16
6801	.....	68	4 1/2	4 3/8	2 1/2
7002	.....	70	4	4 3/8	2 3/8
7003	.....	70	4 1/2	4 1/2	2 1/4
7005	7033	70	4 1/2	4 1/2	2 1/2
7006	.....	70	4 3/8	4 3/8	2 1/4
7007	.....	70	4 3/8	4 3/4	2 3/8
7008	.....	70	4 3/4	4 1/2	2 1/8
7009	.....	70	4 1/2	4 3/8	2 1/2
7010	7040	70*	4 3/8	4 5/8	2 1/4
7011	.....	70	5 1/2	7	2 1/2
7013	.....	70	4 3/8	4 1/2	2 1/4
7014	.....	70	4 3/8	4 3/8	2 5/8
7020	.....	70†	4 1/4	4 3/8	2 3/8
7030	.....	70¶	4 1/4	4 11/16	2 3/8
7101	.....	71	4 1/4	4 1/4	2.4632
7102	.....	71	5 1/2	4 1/4	2 11/16
7103	.....	71	4 3/4	4 3/4	2 1/4
7201	7250	72	4 3/4	4 3/4	2 3/8
7202	.....	72	4 3/4	4 3/4	2 1/2
7203	.....	72	5	6	2 1/4
7204	.....	72	4 1/2	4 11/16	2 5/8
7301	.....	73	4 11/16	4 11/16	2 1/2
7502	.....	75	4 3/8	4 3/8	2 1/2
7503	.....	75	4 3/8	4 3/8	2 1/2
7505	.....	75	4 3/8	4 3/4	2 11/16
7506	7540	75*	4 11/16	4 11/16	2 11/16
7507	.....	75	4 3/4	5	2 1/4
7508	.....	75	5 57	7	2.195
7509	.....	75	5	5	2 11/16
7512	7550	75	4 3/4	4 3/4	2 1/4
7513	7523	75	5	5	2 1/4
7514	.....	75	4 3/4	4 3/4	2 1/4
7524	.....	75	4 1/4	4 11/16	2 1/4
77501	.....	77½	5	5	2 3/8
7801	.....	78	5	4 3/4	2 11/16
8001	.....	80	5	5	2 1/2
8002	.....	80	5	5	2 1/4
8003	.....	80	4 3/4	5	2 1/2
8004	8040	80*	5	5	2 1/2
8005	.....	80	5	5	2 3/8
8008	8022	80	5	5 1/8	2 11/16
8009	.....	80	5	5	2 11/16
8010	.....	80	5	5	2 1/4
8020	.....	80†	4 5/8	5 1/8	2 1/2
8030	.....	80¶	4 1/4	4 11/16	2 1/4
8501	.....	85	4 3/4	5	2 3/8
8502	.....	85	5	5 1/4	2 1/4
8503	8533	85	5	5	2 1/4
8504	8540	85*	5 1/4	5 1/4	2 1/4
8506	8543	85	5 1/4	5 1/4	2 11/16
8507	8550	85	5 1/4	5 1/4	2 11/16
8509	8553	85	5	5	2 11/16
8520	.....	85	4 7/8	5 3/8	2 1/2
8521	.....	85	4 7/8	5 3/8	2 11/16
8524	.....	85	5	5 1/8	2 1/2
8530	8531	85	4 5/8	5 1/8	2 1/2
9001	.....	90	5	5	2 1/8
9002	9040	90*	5 3/8	5 3/8	2 3/8
9003	9023	90	5 3/8	5 3/4	2 3/4
9010	9034	90	5	5 3/8	2 3/8
9020	.....	90†	5 1/8	5 3/8	2 1/4
9021	.....	90	5 1/8	5 3/8	2 1/4
9030	.....	90¶	4 11/16	5 1/16	2 1/4
9501	9540	95*	5 1/4	5 1/4	2 11/16
10001	10040	100*	5 3/4	5 3/4	2 3/4
10002	.....	100	5 1/2	5 1/2	2 11/16
10003	10022	100	5 1/2	6	3
10004	10034	100	5 3/8	6	2 3/4
10005	.....	100	5 1/4	5 3/4	2 1/2
10020	.....	100†	5 1/2	6	2 3/4
10030	.....	100¶	5 1/4	5 11/16	2 11/16
10031	.....	100	5	5 1/16	2 11/16
10035	.....	100	5 1/4	5 11/16	2 1/4
10133	.....	101	5 3/8	5 1/2	2 1/2
11001	11040	110*	6 1/8	6 1/8	2 1/8

Mill Practice in Branding and Heat Number Stamping of Steel Rails

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Lackawanna Steel Company

Section No.	Wt. Rail	Base Inches	Height Inches	Tread Inches
600	60*	4 1/4	4 1/4	2 3/8
600-X	60	4 7/32	4 3/4	2 7/8
650	65*	4 7/32	4 7/32	2 11/32
653	65	4 7/32	4 7/32	2 7/8
654	65	4 5/16	4 11/32	2 1/4
700	70*	4 5/16	4 5/16	2 7/8
701	70	4 5/16	4 3/4	2 1/2
721	72	4 3/4	4 3/4	2 3/8
722	72	4 5/16	4 11/32	2 7/8
741	74	4 3/4	4 11/32	2 7/8
750	75*	4 11/32	4 11/32	2 11/32
752	75	5	5	2 1/2
753	75	5	4 11/32	2 1/2
754	75	4 3/4	4 3/4	2 7/8
775	77.5	5	5	2 1/2
781	78	5	4 3/4	2 11/32
798	79	5 1/2	8	2 1/4
800	80	5	5	2 1/2
801	80	5	5 1/8	2 11/32
802	80	5	5	2 11/32
8031	80†	4 5/8	5 1/8	2 1/2
8032	80¶	4 7/8	4 11/32	2 7/8
804	80	5	5	2 3/8
817	81	6	7	2 1/2
850	85*	5 1/8	5 1/8	2 7/8
851	85	5	5 1/4	2 11/32
852	85	5	5	2 11/32
853	85	5 1/4	5 1/8	2 11/32
8530	85	4 5/8	5 1/8	2 1/2
8531	85	4 7/8	5 3/8	2 11/32
855	85	5 1/8	5 1/8	2 11/32
900	90*	5 3/8	5 3/8	2 5/8
901	90	5	5 1/2	2 11/32
902	90	5	5	2 1/2
903	90	5 3/8	5 1/2	2 11/32
9030	90	5	5 3/8	2 5/8
9031	90†	5 1/4	5 3/8	2 7/8
9032	90¶	4 11/32	5 11/32	2 7/8
9033	90	5 1/8	5 3/8	2 7/8
911	91	5 3/8	5 1/4	2 5/8
951	95.4	5 1/2	5 1/8	3
957	95	6	7	3
1000	100*	5 3/4	5 3/4	2 3/4
1001	100	5 1/2	6	3
1002	100	5 1/2	6	2 3/4
1003	100	5 1/2	5 1/2	2 11/32
1030	100	5	5 11/32	2 11/32
1031	100†	5 1/2	6	2 3/4
1005	100	5 3/4	5 3/4	2 7/8
10130	101	5 3/8	5 1/8	2 3/4
1051	105	5 1/2	6	3

Cambria Steel Company

Section No.	Weight Rail	Base Inches	Height Inches	Tread Inches
514	60	3 1/4	4	2 11/32
509	60	4 1/8	4 1/2	2 1/8
527	60	4 1/4	4 1/2	2 5/8
571	60¶	3 1/8	4 1/2	2 5/8
568	60†	4	4 1/2	2 5/8
533	60*	4 1/4	4 1/2	2 5/8
518	65	4 1/8	4 1/2	2 1/2
534	65*	4 1/8	4 1/2	2 11/32
515	67	4 11/32	4 1/2	2 11/32
547	66	4 1/2	4 1/2	2 1/8
516	68	4 1/2	4 1/2	2 11/32
532	70*	4 1/2	4 1/2	2 1/8
504	70 and 72	4 1/2	4 1/2	2 1/8
570	70¶	4 1/8	4 11/32	2 1/2
567	70†	4 1/4	4 1/2	2 5/8
528	75	4 3/8	4 5/8	2 1/8
529	75*	4 11/32	4 11/32	2 11/32
530	80*	5	5	2 1/2
540	80	4 11/32	5	2 11/32
543	80	5	5 1/8	2 11/32
569	80¶	4 1/8	4 11/32	2 1/2
566	80†	4 1/8	5 1/8	2 5/8
506	85	5	5	2 11/32
500	85	5	5	2 1/8
531	85*	5 1/8	5 1/8	2 1/8
559	85	4 1/2	5 1/2	2 5/8
561	90¶	4 11/32	5 1/2	2 1/8
563	90†	5 1/8	5 1/2	2 1/8
535	90*	5 1/2	5 1/2	2 5/8
560	95*	5 1/8	5 1/8	2 11/32
558	100	5	5 11/32	2 11/32
520	100	5 1/2	5 1/2	2 11/32
564	100¶	5 1/8	5 11/32	2 11/32
565	100†	5 1/2	6	2 5/8
536	100*	5 3/4	5 3/4	2 5/8
572	110	5 1/2	6	2 11/32
573	120	5 3/4	6 1/4	2 1/2
574	130	6	6 1/2	2 11/32

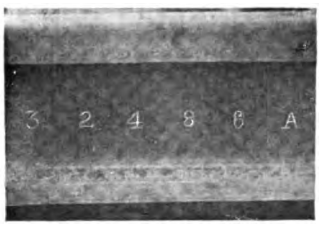
Dominion Iron & Steel Company

Section No.	Wt. Rail	Base Inches	Height Inches	Tread Inches
6001	60	4 1/4	4 1/4	2 3/8
6501	65	4 1/2	4 1/2	2 1/2
7001	70	4 5/8	4 5/8	2 5/8
7501	75	4 11/32	4 11/32	2 11/32
8001	80	5	5	2 1/2
8002	80	5	5 1/8	2 1/2
8003	80	5	5	2 1/2
8501	85	5	5 1/8	2 11/32
10001	100	5 3/4	5 1/4	2 3/4

Colorado Fuel & Iron Company

Section No.	Wt. Rail	Base Inches	Height Inches	Tread Inches
603	60*	4 1/4	4 1/4	2 3/8
653	65*	4 7/32	4 7/32	2 11/32
701	70*	4 5/16	4 5/16	2 7/8
753	75*	4 11/32	4 11/32	2 11/32
754	75	5	5	2 1/2
756	75	4 1/4	4 1/4	2 3/8
757	75	4 7/32	4 11/32	2 7/8
800	80*	5	5	2 1/2
801	80†	4 1/4	5 1/8	2 1/2
850	85	5 1/4	5 1/4	2 1/2
851	85*	5 1/8	5 1/8	2 3/8
852	85	5 1/8	5 1/8	2 11/32
853	85	4 1/2	5 1/2	2 1/2
900	90*	5 1/8	5 1/8	2 5/8
902	90†	5 1/8	5 1/8	2 5/8
903	90	5 1/8	5 1/8	2 11/32
904	90	5	5 1/2	2 5/8
905	90¶	4 11/32	5 1/2	2 11/32
950	95*	5 1/8	5 1/8	2 11/32
1000	100*	5 1/8	5 1/8	2 11/32
1002	100¶	5 1/8	5 1/8	2 11/32
1100	110*	6 1/4	6 1/4	2 1/4

*Indicates ASCE section rails.
†Indicates ARA series A section rails.
¶Indicates ARA series B section rails.



Typical Rail Blow Mark

Trasco Rail Chair
The Track Specialties Co.

Typical Rail Brand

Vaughn Rail Support
The St. Louis Frog & Switch Co.

heat marks are sometimes indented in the steel. The other symbols of the brand are rolled in the rail in raised letters and figures. See Rail (Specifications).

RAIL, BROKEN. A rail which has broken through and separated into two or more parts. A crack which may result in a complete break is classified under this head. See Rail Failure.

RAIL CHAIR. A rail bearing casting designed to be fastened to a cross tie for the purpose of holding a rail or the ends of contiguous rails, by means of a contrivance which clamps about the rail flanges. Rail chairs are in general use on the tracks of some railways in Europe, notably in Great Britain. See Rail Joint. Also Tie Plate.

RAIL CREEPING. The intermittent, minute, longitudinal sliding movement of rails in track. Rails creep from two principal causes: (1) The application of brakes to moving car wheels which retards the motion of the train by increasing the friction between the wheels and the rails. (2) The undulating rail or wave motion due to the depression of the rails under the intermittent rolling loads of the wheels of passing trains. Factors tending to promote creeping are an insufficient expansion allowance, loose spikes and bolts, long spaces between ties, yielding foundations and lack of drainage.

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In general, the tendency is for rails to creep in the direction of heaviest traffic, though there are occasional exceptions. Rail creeping is most likely to occur in tracks laid across swamps, down descending grades, at approaches to bridges and sharp curves, at slow order boards, at approaches to interlockers, in ladder tracks in yards, at station shops, and at all places where train brakes are customarily applied. Rails creep less in freezing weather than in summer. Rail has been known to creep up steep grades, as well as on level grades across swamps where it has been observed to creep first one way and then the other under trains moving in opposite directions. One line of rail of a track has been observed to creep faster than the other, especially on double track lines. One line of rail has even been known to creep while the other line of rail of the same track did not, or the two lines of rail have been known to creep in opposite directions. Rail which has never crept may suddenly start moving or the creeping may change direction.

Among the first evidences of rail creeping are the closing of successive expansion spaces in the direction of creeping and the opening of the joints at the point from which the creeping starts. Marks begin to show on the rail flanges where the spike heads scrape the rails as they slide. The joint ties are slewed and crowded ahead, forcing the ballast ahead of them and leaving crevices in the ballast behind them. Crossing frogs and switch points are pushed out of line. There is danger of track kinking where the tendency to creep is severe and continuous for long distances. The remedy for creeping rails is to drive them back to their original positions and anchor them there. If they were laid with too little expansion in the first place, a piece may be cut from the end of one rail and the space thus obtained distributed as the rails are driven back. The anchoring should start back of the point where the creeping first became noticeable. It is considered good practice to install anti-creepers without stint on the approaches to sharp curves, steep grades, bridges, ladder tracks, swamps and other places where creeping has or may occur. In general it is of ultimate economy to apply the preventive plentifully at the source of creeping rather than sparingly in the midst of it.

RAIL, DAMAGED. A rail which has been injured during its service in the track, as distinguished from a rail which shows defects of manufacture. For example: a rail which is bent as a result of a train wreck, or nicked by a broken wheel tread, is damaged, whereas a piped rail is defective.

RAIL, DEFECTIVE. A rail which shows some imperfection due to faulty manufacture, as distinguished from a soundly made rail which is damaged during its service. For example: a piped rail is defective while a rail injured in a wreck or by a broken wheel is damaged.

RAIL, EASER. A rail designed to prevent a worn wheel tread from striking the head of a running rail of a frog or crossing. The easer rail is so machined that its head fits against the outside of the head of the running rail, and is so bent as to gradually lift a worn wheel tread to the elevation of the top of the running rail so that it may pass over this rail.

RAIL FAILURE. A break or any other defect which necessitates removing a rail from main track.

The term broken rail is confined to the rail which is broken through and separated into two or more pieces; or so cracked so that a complete break may result therefrom. Defects classed as rail failures include flow of metal, crushed and split heads, split webs and broken bases; while damaged rails are those which are nicked by broken wheels; or bent, kinked, broken or otherwise injured as a result of derailments or other accidents.

Although the new rails laid in main track will commonly last for several years before any considerable percentage of the rolling shows signs of failing, any defective rails laid usually develop faults within a few weeks or months and later failures are less numerous.

While the primary causes of rail failures seem to be largely attributable to inherent defects in the steel, some are undoubtedly due in whole or in part to rough handling of the finished rail, to poor track construction or maintenance, to defective equipment, to improper operation or to overloading. Steel is notably brittle or sensitive to shock in cold weather, and rail failures increase during severe winter seasons. Notwithstanding the many causes of failure due to imperfections in the steel and the severe service to which they are subjected, probably less than one-tenth of one per cent of all the rails used fail in the track. However, the possible serious consequences of such failures make them of vital importance. It is commonly contended among trackmen that the oldest rails are the best and that the rails last put in service are the most defective. As a matter of fact, the defective old rails have probably long since been removed from track and forgotten, and only the soundest are still in service, while the few defective new rails are more in evidence.

Rails are subject to failures which may start in the head, the web, or the base. The two most common classes of head failures are crushed and split heads. Crushed heads are those which broaden, flatten and sag on one or both sides, showing preliminary dark streaks along the top of the rail, which indicate depressed surfaces. This defect may be the result of segregation, due to the poor mixture of elements and consequent collection of carbon, sulphur, phosphorus, etc., at the center near the top of the ingot, or it may result from blow-holes or gas seams; it is also claimed that flat and slipping wheels tend to cause the same type of failure. When a crushed head develops at the end of a rail it may be partly the fault of the joint, due to weak joint bars, poor support and loose bolts which tend to cause the battering of the rail ends under traffic. Rails should be removed before these defects develop so far as to ruin the section or become unsafe.

Split heads are often confused with crushed heads, although the true split head occurs unaccompanied by crushing, a piece a few inches to several feet in length splitting off the head and dropping away from the rail. Split heads are usually due to segregation or seams, but they may occur from a pressing outward of the metal under traffic or from a defective wheel. Split and crushed rail ends usually result in short pieces of the head about one to

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three inches long dropping off one side or the other, or in failures through the end bolt holes. If a small corner cracks off a rail end on the outside of the track it may not be necessary to remove the rail at once, but if it breaks from the gage side, the rail should be taken out as soon as possible.

Flow of metal from the crown is a defect which results in lips overhanging the section of the head of the rail. The flow may occur in a small spot or throughout the length of the rail. In small spots it may be caused by slippage of wheels or by blow-holes, gas seams or improper heating in the mill. End flow of metal may also be due to weak joints or defective maintenance. The flow of metal in stock rails at switches is usually due to conditions arising from the false flanges of unequally worn wheels. Metal flow throughout the length of a rail may be due to soft metal from the surface of the ingot, which is deficient in carbon, or to abrasion from wheels with worn flanges or to wide gage on curves. These are not usually dangerous defects and the rails need only be removed when indications are that the wear is becoming excessive.

A dangerous type of head failure which has received attention only within the last decade is the transverse fissure, an internal defect in the metal in the head of the rail. It usually appears in the fractured rail section as an interior silvery-white, smooth, oval spot with granular nucleus, the metal surrounding the oval spot having the usual crystalline structure. Occasionally the top portion of the fissure turns back and runs parallel with the top of the rail about half an inch below it, and a few cases have been noted where the entire fissure is horizontal. It appears that the fissure radiates from an over-strained fibre of the metal, the primary cause of which is believed to be due to some defect in manufacture, as widely distributed rails of the same heat are found to have the same defect, while those laid adjacent to the fissured rails and carrying the same traffic are sound. It is likewise claimed that this class of failure is in part a result of over-straining the metal in service. In any case, the transverse fissure develops without warning or previous exterior indication, and all rails of the same heat as the fissured rail should be removed from main track, as they are likely to have the same dangerous defects. It is the trackman's duty to examine the grain of the steel in broken rails minutely with a view to determining whether a fissure or some other defect caused failure.

A piped rail is dangerous principally because it is invariably accompanied by segregation, which is also the usual cause of crushed and split heads. A pipe is a shrinkage defect due to the cooling of the ingot from the outside toward the center, leaving a conical cavity in the center of the section near the top, which portion should be discarded. Short, wide ingots and those cast with the wide ends up have less tendency to pipe than the long tapering forms. Since the pipe always occurs at or near the center of the section of the ingot if cooled while standing vertically, as is the rule, it appears usually as a web defect in the finished rail. The walls of a pipe are smooth and dark, showing that the defect is the result of pressing together two disunited metal surfaces. Sometimes a piped rail shows a dark streak

A. B. & C. R. R. Co.

No.....

.....Division.....Branch.

REPORT OF RAIL FAILURES IN MAIN TRACKS

Section No..... Date of Report.....191...

1	Weight per yard, New.....lb Re-rolled .....lb	16	Was Rail much or little worn?.....
		17	By whom discovered.....
2	Rail Section?.....	18	Date and Time found?.....
3	Brand on Rail? ("D" on back).....	19	Was Rail removed?..... Date removed? .....
4	Kind of Steel? ("E" on back).....		
5	Heat No. on Rail? ("F" on back).....	20	Exact gage of Track at "Break"?....
6	Rail No. or Letter? ("F" on back)....	21	Was "Break" over or between Ties?..
7	Original Length of Rail?.....	22	Was "Break" square or angular?....
8	Month and Year Rail was Laid.....	23	Distance between edges of Ties at "Break?" .....
9	Location .....Feet .....of Mile Post		
10	Which Track?..... Which Rail?	24	Condition of Ties each side of "Break?" .....
11	On Curve or Straight Line?.....	25	Kind of Ties? .....
11½	No. of Curve?.....	26	Were Tie Plates used?..... Kind? .....
12	Degree of Curve?.....		
13	High or Low Rail, if on Curve?.....	27	Condition of Line and Surface?.....
14	Superelevation of Curve at "Break"?..	28	Kind of Ballast?.....
	.....	29	Was Track properly ballasted?.....
15	Was Rail "Broken"?..... or "Defective"? ..... or Damaged? ..... (See "Description of Failures" on back)	30	Kind of material in roadbed under ballast? .....
		31	Was Track well drained?.....
		32	Was Roadbed frozen?.....

33 Condition of weather? (Wet, dry, warm or cold, freezing or thawing).....

34 If "Broken," state cause of break, and describe any flaws found at point of break .....

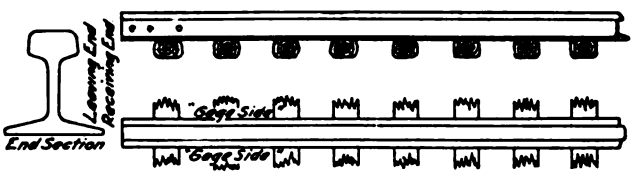
35 If "Break" was at joint, state kind, number of holes, and whether it was full bolted or insulated.....

36 Were any bolts at joint loose?.....If so, how many?.....

37 Was accident or detention to trains caused by "Break"?.....
If so, state circumstances.....

38 If "Defective," describe kind and location of flaws or defects, and if possible, what caused them. (See "Description of Failures" on back).....
.....
.....

39 Draw on Diagram lines of "Break," or partial fracture, such as long pieces from side of head and half-moon pieces from base, showing dimensions. Hollows in head should be shown on "End Section." Defects may also be indicated on Diagram. Mark distance from end to "Break." *If "Break" is nearest "Receiving End," draw pen through words "Leaving End" it nearest "Leaving End," draw pen through words "Receiving End" (*Refers to track upon which the current of traffic is in one direction.) Indicate "Gage Side" on "Diagram" below, by drawing pen through words "Gage Side" on opposite side.



40 If "Damaged," describe nature and cause if known. (See "Description of Failures" on back).....

Correct: Approved:

.....Foreman. .....Supervisor.

A. R. E. A. Rail Failure Report

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in the bright surface of the crown directly over the web before failure. Such a rail should be removed from track at once, for it may fail at any moment. Crushed heads are easily mistaken for pipes, but rails showing either of these classes of failures should be removed from the track at once.

Base failures, known as half-moon breaks, result usually from seamy steel, and, it is claimed, in some cases from gagging. The seams are sometimes marked, sometimes obscure and usually located close to the center of the base. The crack starts and continues along this line, sometimes for several feet, but usually only a few inches, until from each end it breaks out to the edge of the flange in a curve, and the crescent-shaped piece drops down. Half-moon breaks occur usually over ties, are most common in rails with thin bases and are most prevalent in severe winter weather. The thick bases of the A. R. A. sections of rail were designed partly to overcome this defect. These seams occur principally in the surface steel of the ingot, which is apt to be low in carbon and pitted from bubbles of air, entrapped by the rapidly rising molten metal as it is poured into the molt. To eliminate these seams, a layer of steel ⅛ in. to ¼ in. deep is sometimes milled from the top and bottom of the partly formed hot rail bar during the rolling. A rail with a moon-shaped break in the base may be left in a main track temporarily if drilled so that a pair of joint bars may be applied over the break, although it is advisable to replace the rail at the first opportunity.

Rails may be injured by being thrown from moving trains against boulders or other rails, or hard, uneven ground while being unloaded. They may also be injured in track by blows from a spike maul, base failures and split heads being sometimes ascribed to inaccurate spiking, to uselessly hard tapping of the spikes, and to striking the top of a rail with a steel maul. If a rail must be struck, a wood block should be held against it to soften the shock of the blow of the maul. Rails may be injured by cold straightening or bending as in improperly surfaced track, while such defects as loose bolts, low joints, improper super-elevation and gage, poor shimming and the reversing of the bends in curved rails tend to shorten their lives. The skidding of locomotive drivers burns the crowns of rails, makes the top metal brittle and causes depressions in the rail heads which may ultimately result in complete failure, or the slipping may be due to the excessive use of breaks which also cause flat wheels, which pound and tend to break the rails. Improperly counterbalanced drivers will do great damage, and one nicked car wheel flange may ruin many rails in one trip. Worn locomotive tires overload the outer edge of rail heads and leave unusual marks which are easily identified. Excessive train speeds accentuate the defects inherent in rails and so contribute toward rail failure. The importance of a standard method of reporting on the failures of main track rails, with a view to uniformity in the details of information which may lead to the identification of the various classes of defects and their remedies is recognized generally by railway engineers and by the A. R. E. A., which has adopted the forms shown on pages 130 and 131.

INSTRUCTIONS

A. The Foreman will send this Report to the Supervisor the same day the break is discovered, and in the case of a damaged or defective rail, the day it is taken out of the track.

B. The Supervisor will forward this Report direct to the Division Engineer.

C. The Division Engineer will have copies of this Report made immediately upon receipt and send a copy to the Chief Engineer M. of W.

D. The answer to 3 is in raised characters on the web of the rail.

E. The answer to 4 is "Bessemer" (B); "Open-Hearth" (O.H.); "Nickel" (N.); "Ferro-titanium (F.T.); "Chrome Nickel" (C.N.); or other method of manufacture or alloy.

F. The answers to 5 and 6 are stamped into the metal on side of web—figures for 5 and a letter for 6.

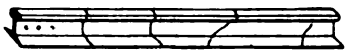
G. Mile Post No. from { South / East } end of Division to be used.

DESCRIPTION OF RAIL FAILURES

When describing Failures of Rails, the following terms should be used.

DEFECTIVE.

1. BROKEN RAIL. This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

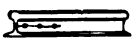


2. FLOW OF METAL. This term means a "Rolling Out" of the metal on top of the head towards its sides without there being any indication of a breaking down of the head structure, that is, the under side of the head is not distorted.

3. CRUSHED HEAD. This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.

4. SPLIT HEAD. This term includes rails split through or near the center line of the head, or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.

5. SPLIT WEB. This term is a longitudinal split along the axis of the web, generally starting from the end of rail through the bolt holes.



6. BROKEN BASE. This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.

7. DAMAGED. Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.

A. R. E. A. Foreman's Rail Failure Instructions

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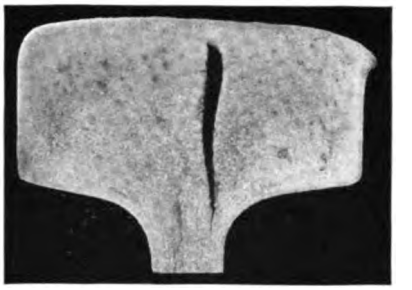
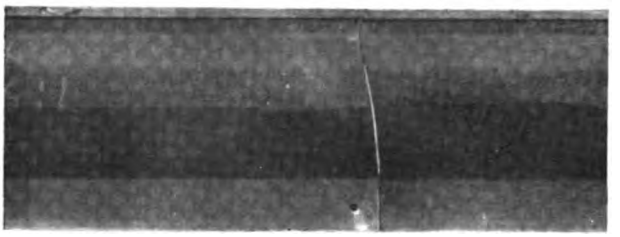
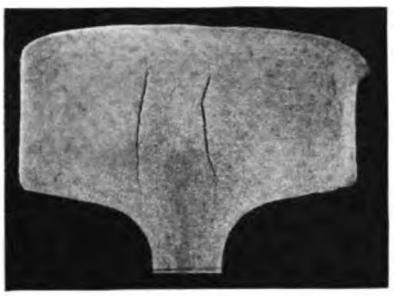
Flow of Metal



Splitting Head

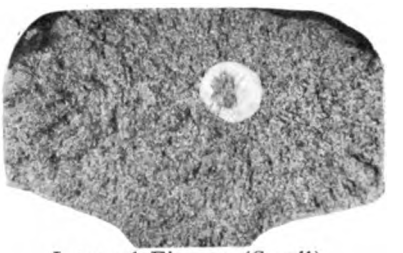


Broken Rail



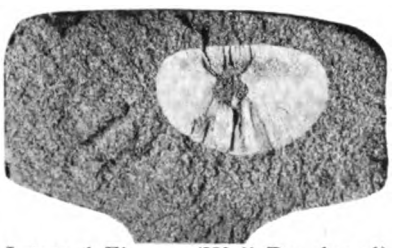
Segregation

Split Base



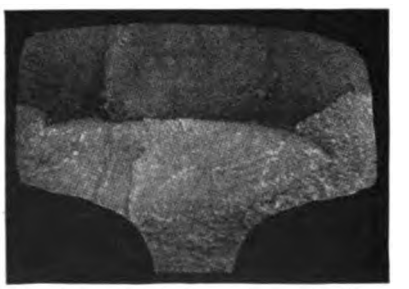
Internal Fissure (Small)

Split Web



Internal Fissure (Well Developed)

Broken Base (Half Moon Break)



Coalescent Internal Fissure

Typical Rail Failures

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RAIL FORK. A steel bar usually 33 in. long over all, divided into two parallel prongs 4 in. long at the working end of the square-sectioned shank, which tapers to a handle 1 in. in diameter and 20 in. long.

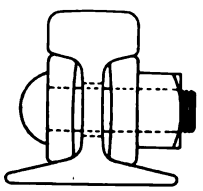
A Rail Fork

This tool, which somewhat resembles a track wrench, is used principally to roll and unload rails from flat cars by applying leverage to the handle while the rail flange is held between the close set prongs.

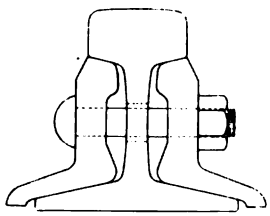
A rail fork which has prongs and shank of 1⅜ in. square steel weighs about 15 lb. Two experienced men, one at each end, can roll a rail from a pile readily with rail tongs. In case a rail slants across a pile, one end can be moved to bring it parallel with the other rails by lifting on the fork while holding the end of the web between the prongs.

RAIL, HIGH. A rail laid in the outside of a super-elevated curved track.

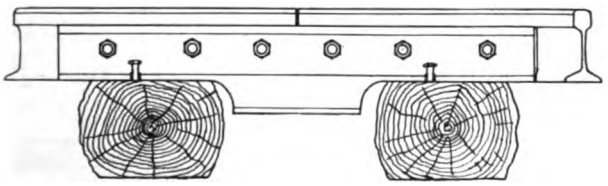
RAIL JOINT. A fastening designed to unite the ends of contiguous rails of a railway track. This term commonly includes all the joint fastenings which contribute to the connection and support of the abutting rail ends.



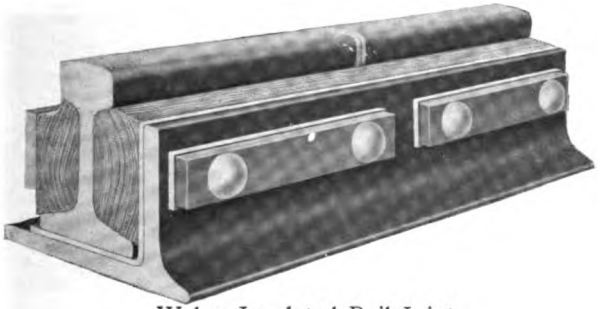
Section Across a Fish Plate Joint



Section Across an Angle Bar Joint



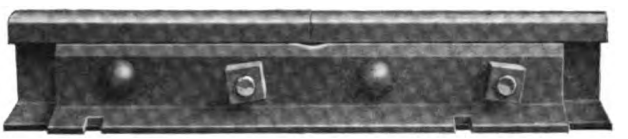
Du Quesne Rail Joint
The Carnegie Steel Co.



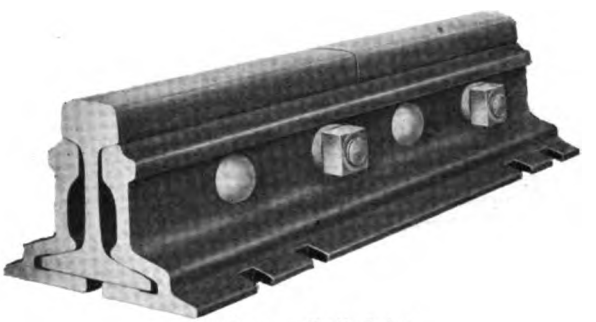
Weber Insulated Rail Joint
Rail Joint Co.
(See Page 782)

The development of the rail joint in America has proceeded from the rail chair to the fish plate, then to the plain angle bar, and later to the various modified joint bars now generally in use in connection with "T" rail sections. Rail joints have been variously designed with a view to obtaining the ideal general effect of the continuous girder. Joint bars which extend below the base of the rail are sometimes called bridged joint bars and the joints are called bridged joints. Various styles of rail joints are further reinforced by base plates.

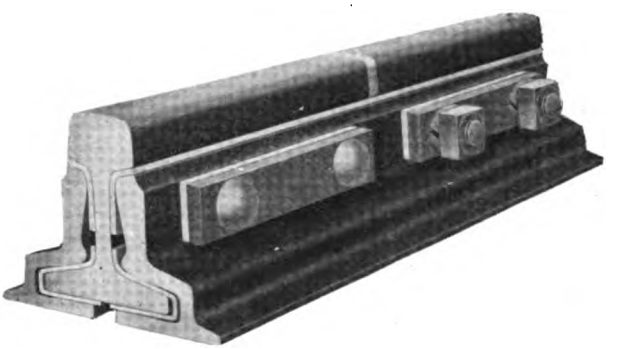
The base plate may be a plain flat steel plate of sufficient area to support the bases of the joint bars with enough margin to extend an inch or more beyond the spikes for which holes are punched in the plate. Base plates of recent design, however, are upset at the ends for the purpose of holding the joint bars in place endwise to minimize the tendency toward rail creeping, while other styles are also raised at the sides and depressed below the bottom of the rail at the center to lend stiffness to the joint between the ties and beneath the ends of the joined rails. Some joint bars are bent under and across the rail base to form a base plate extension, the mate bar having no extension, or both bars are folded under, their adjacent edges almost meeting beneath the axis of the rail.



Lackawanna Safety-Head Angle Bar Rail Joint
The Lackawanna Steel Co.



Continuous Rail Joint
The Rail Joint Co.
(See Page 780)



Continuous Insulated Rail Joint
The Rail Joint Co.
(See Page 782)

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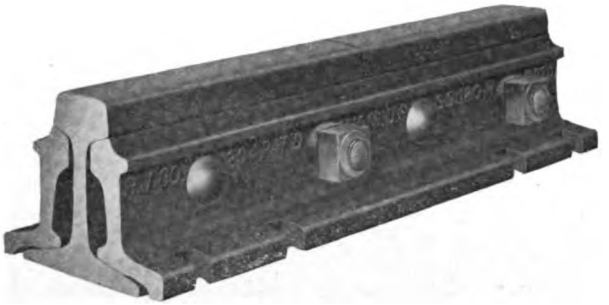
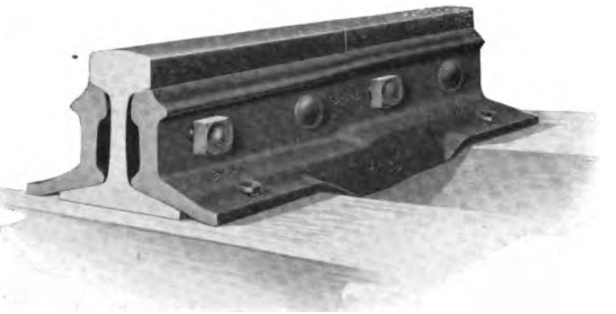
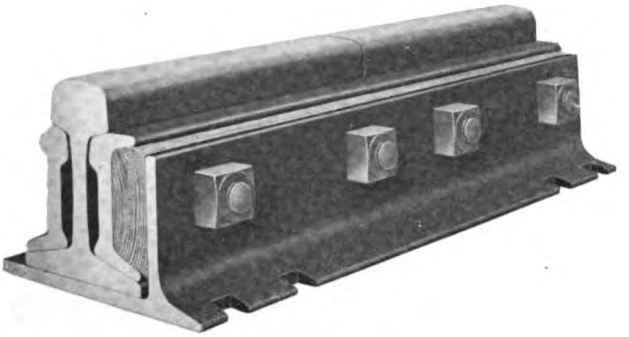


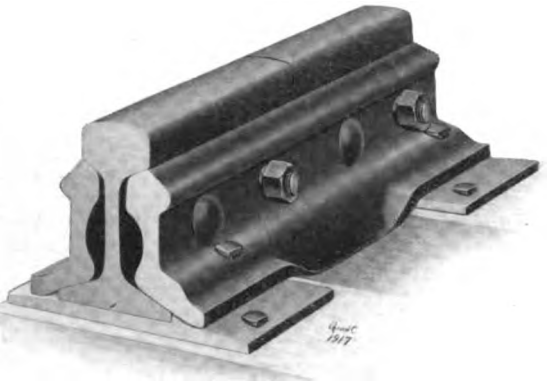
Modified Angle Bar Rail Joint
The Rail Joint Co.
(See Page 781)



Compromise Rail Joint
The Q & C Co.
(See Page 776)



Weber Rail Joint
The Rail Joint Co.
(See Page 781)

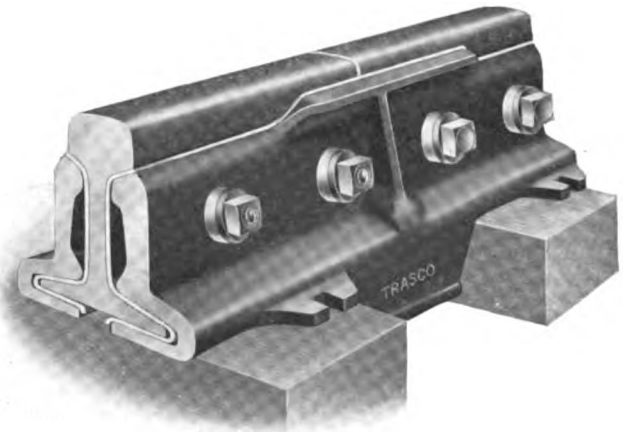


Bonzano Rail Joint
The Q & C Co.
(See Page 776)

Continuous Compromise Rail Joint
The Rail Joint Co.
(See Page 781)

Atlas Compromise Joint
The Atlas Railway Supply Co.

Reading Compromise Rail Joint
The Reading Specialties Co.



Trasco Insulated Rail Joint
The Track Specialties Co.

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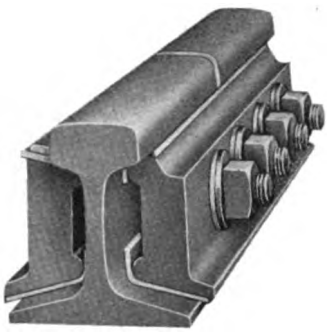
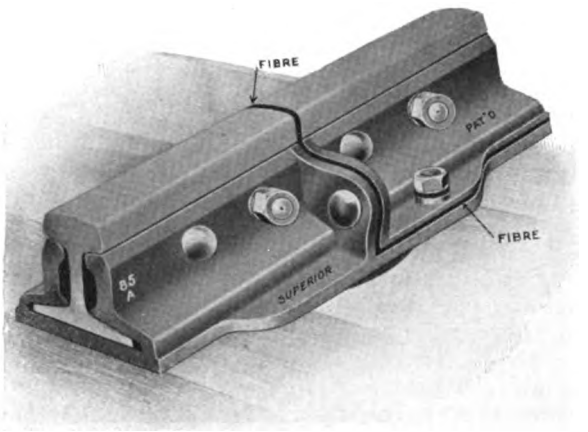
Recent design has tended toward the development of an angle bar with increased metal in the top edge or head, to provide greater strength and area of contact and support to the under side of the rail head. At the same time, designs providing reinforcement at the base of the joint have received attention, as well as tapered bars providing flexible, hinge-like rail joints. These designs generally retain the feature of wedging fits against the under side of the rail head and the flange angle at the base of the rail.

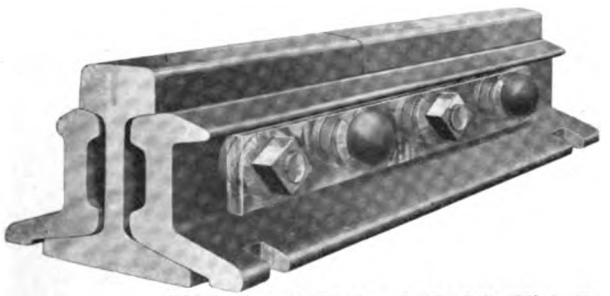
to minimizing the restriction of wave motion through the rail joint, the anchoring being done at the centers and quarters of the rails, rather than at the ends. In some designs the joint bars are shaped to prevent the heads of the rail ends from chafing, nicking and tending to crack the bar from the top, which for this purpose is slightly depressed at the center where the rail heads join. In others the bottom legs are bent down and inward to form a groove, in which the base of the rail fits and is supported. Some rail joints have base plates which



Keystone Insulated Rail Joint
The Union Switch & Signal Co.



Trasco Insulated Rail Joint
The Track Specialties Co.



Hatfield Rail Joint and Hatfield High Tension Spring for Application to Angle Bar Joint
The Hatfield Rail Joint Manufacturing Co.
(See Page 702)

Considerations which affect the design of rail joints include the wheel load, the position of the joint on the ties, the section drilling of the rail, the allowances for contraction and expansion due to temperature changes, the vertical clearance between the bolt holes and wheel flanges, the methods of fastening, the motion of the rail ends under traffic and the consequent wear of the members of the joint.

It is the general practice to stagger the bolts in a rail joint, placing the nuts of alternate bolts on the inside of the track, providing wheel flanges will clear them, to avoid the possibility of a derailed flange scraping more than half the nuts from any one joint. When track was laid with the rail ends opposite, supported joints and six-hole joint bars were commonly used. With the general adoption of the broken-joint method of laying rails in recent years, the suspended joint and the four-hole angle bar have come into use and a tendency has developed toward sturdier but shorter joints with a view

are extended, cambered and bent trusswise, to add to the bottom support afforded the joint and to act as anti-creepers and tie plates. A recent general development is the heat treating of steel joint bars to obtain the requiste strength and toughness to withstand the various stresses imposed on the joints by traffic.

In addition to the joint bars other members of the rail joint are the threaded track bolts and nuts which hold the joint bars and rail ends in place, the base plate, if any, the nut locking devices; and, with insulated joints, the fibre end posts and other insulating parts, or in the case of bonded rails, the bonding device.

Special rail joints are necessary to unite rails of different heights and sections. These joints are so made as to bring the gage sides and the crowns of the joined rail heads into line and to support them in that relative position so that continuous smooth surfaces are presented to the treads and flanges of passing wheels. These rail joints are called compro-

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mise joints and the bars are called compromise joint bars. Tapered rails are sometimes used for the same purpose.

The combination of yielding foundations, successive blows of passing wheels, wave motion, contraction and expansion in rails and side thrusts from wheel flanges, cause severe strains on rail joints. The steel joint bars are therefore rolled to true smooth surfaces to obtain good contact with the rails. The bolts are carefully formed and threaded out of steel of high tensile strength. Spring washers are used to avoid battering the threads on the edges of rail bolt holes as well as to maintain the bolts in tight adjustment.

A matter of primary importance in the maintenance of rail joints is the adjustment of track bolts. It is obvious that loose bolts allow joint bars to chafe and break, permit threads to batter and nuts and nut locks to be lost. Bolts should not be tightened periodically, but should be cared for daily and thus kept tight continuously. If screwed too tight, they may be stretched, and even if not stretched in tightening with the wrench, the movement of the joint under traffic may strain the bolts beyond their yield point. If bolted too tightly the individual rails may be prevented from expanding and contracting, thus concentrating the expansion at certain long intervals. It is considered good practice, therefore, to keep bolts continuously tight enough to hold the joint firmly but not so tight as to tend to prevent the expansion and contraction of the rails. Efficient rail joint maintenance involves intelligent daily inspection and care, including periodical oiling of track bolts and other fastenings to prevent deterioration from rust.

RAIL JOINT BASE PLATE. A horizontal plate designed as a bed for the bases of both rails at a joint, to prevent vertical movement and to add strength to the rail joint. In order to prevent the joint bars from slipping the base plate is frequently upset at the ends and sometimes on the sides near the ends. The edges of some base plates are bent down and inward at the middle thus strengthening the section beneath the rail ends. Joints in which any parts extend thus below the level of the rail bases must be installed as suspended joints, which ordinarily necessitates moving about 40 per cent of the joint ties of track formerly laid without regard to the positions of joints on the ties.

RAIL JOINT, BONDED. A rail joint provided with a metallic connecting link such as a wire or wires or a metal strip, the opposite ends of which are firmly fastened to the adjoining rails, thus bonding them electrically to insure the continuity of the electric track circuit. Rails within the limits of a track circuit are bonded because the joint bars and fastenings of the rail joints cannot be depended on to maintain a sufficiently firm contract for this purpose unceasingly.

For circuits such as those employed in the operation of automatic signals or crossing bells, present practice favors 2-No. 8, B. W. G. galvanized iron E. B. B. bond wires, with their opposite ends fastened by means of channel pins in separate holes 9/32 in. in diameter drilled through the webs of abutting rails about 4 in. back of the ends of the joint bars; except in locations where unusual electrical obstructions exist, as at grade crossings and bridges with steel guard.

Bond wires are commonly made of ample length to clear the joint fastenings, the opposite ends being wedged into holes drilled through the webs of contiguous rails beyond the ends of the joint bars so that the joints may be repaired without disturbing the wires. Although some bond wires are only a few inches long and are riveted to the rails above the joint bars, the attachment is usually made by means of a hollow, split, cone-shaped metal channel pin. The end of the bond wire is thrust through the pin, which is then driven home with a wedge action into the hole in the web of the rail. Some rail bond wires are placed between the rail and the joint bar, while others are carried outside and above the head of the joint bar. They consist of single wire, or less commonly of strips of plate metal, or multiple strand wire. (See Page 825).

A Bonded Rail Joint

RAIL JOINT, INSULATED. A rail joint designed to arrest the flow of electric current from rail to rail, as at the end of a track circuit, by means of non-conductors so placed as to separate the rail ends and other metal parts. To maintain the strength of the joint and at the same time insulate the parts effectively, the non-conductors are designed to conform to the shapes of the joint members, to be as thin as possible and to resist abrasion and the effects of the elements.

Wood blocks are used instead of, or in addition to, metal joint bars in some types of joints. However, wood is considered too fragile for end posts, and dense insulating fibre about ¼ in. thick is now in general use for this purpose. It is inserted between rail ends for fibre end posts, between rail bases and metal base plates, between joint bars and rail webs, and as insulating ferrules and washers for the bolts and nuts of the joint.

Intelligent maintenance is required to keep insulated rail joints in condition to function properly in all weather and under the vigorous conditions imposed by dense traffic over the tracks. The character of the ballast exerts considerable influence especially in humid climates and during periods when the tracks heave with alternate daily freezing and thawing. Cinders especially retain frost and moisture, the porosity of this ballast material being a reason for using it as a bottom rather than a top ballast in territory where insulated joints are necessary.

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To obtain the best results from insulated joints, the track should be kept well tamped on a liberal cushion of non-porous ballast, and care should be observed in maintaining the fibre end posts as well as thimbles and all other insulating fibre in first class condition. If the joint is maintained on a foundation sufficiently unyielding to offer proper resistance to bending under the wheels of rolling stock, the insulation will wear much longer than if there is friction among the parts.

RAIL JOINT, PUMPING. A rail joint on a foundation so poorly drained that the vertical movements under passing wheels cause mud to form under the tie and to be churned or pumped up through the ballast by the joint ties.

Pumping joints are frequently found in railroad crossings and at turnout frogs, which are not easily removed to improve the drainage. There is no known track joint of material and design so excellent that it will long resist the uncurbed effects of defective drainage, and resultant track evils.

RAIL JOINT, SUPPORTED. A rail joint in which the rail ends are placed on a tie. A disadvantage of a rail joint on a one-tie support is that the joint bars tend to break at the spike slots, while those supported on three ties necessitate long joint bars which require one-third more steel and fastenings than joints suspended between two ties, and give no better results.

Suspended Rail Joint on Slag Ballast
Bessemer and Lake Erie

RAIL JOINT, SUSPENDED. A rail joint in which the rail ends are between two ties. In relaying rail in broken joint track only about 60 per cent of the joints come between the ties, so that to obtain properly suspended joints the ties have to be respaced. This involves the removal of the top ballast, shifting the ties off or partly off their beds (with some danger of reducing their service life), retamping them in the new locations, and replacing and redressing the ballast. Furthermore, the track will not stay in as good surface as formerly until the ties become as solidly bedded as they were in their old positions. There will be some slight movements among the particles of ballast until the drainage is accommodated to the new conditions. The moving of joint ties thus ordinarily increases maintenance expenses and adversely affects the track conditions for a period of several months. There is in consequence a growing tendency on some roads to disregard slot spiking and the positions of the relaid rail joints on the ties, as being of less disadvantage than the disturbance of the ties and the ballast. This tendency is not so marked, however, as to materially alter the general standard of the suspended joint.

RAIL, LOW. A rail laid in the inside of a superelevated curved track.

RAIL, RELAYER. A used rail suitable for main track service.

Once-used rails are usually far from being worn out when they are first removed from main track, where they have probably spent only 20 per cent to 25 per cent of their total service life. The condition of wear of the various rails removed from a main track in one continuous line will commonly vary widely. When the general average of the rail is such as to lead to the removal from track, some rails may still be suitable for relaying in main track without repair, while others may be a little surface bent, needing only new joints for further main track service. Some rails that are flange worn in curved track may be changed end for end, bringing the unused side to the gage side of the track, while others may be sorted out for secondary tracks, for resawing or for rerolling. It is usual to inspect, classify and mark once-used steel as soon as it is discontinued, and while the rails are lying along the road bed. Main track relaying rail is classed according to the wear on the crown and side of the head at the gage line.

Class 1 relayer rails must be sound enough to pass the A. R. E. A., specifications for steel rail in every respect excepting wear. They must be in fair surface without burnt or flat spots, with sawed ends, uniform drilling and of full length. Class 2 relayers are those with split, battered, chipped, broken and depressed ends which, when resawed, will make Class 1 relayers, 27 ft. long or longer, although 10 per cent may saw shorter than 27 ft. Class 3 relayers include all side track rails not suitable for Class 2 or resawing rails, which are usually selected from those that are evenly and moderately worn in section, but which have defective ends.

When a preponderant percentage of the rail of a given lot is of good section but surface bent, it is commonly resawed. In its surface bent condition it makes rough riding track, is destructive of equipment and tends to grow worse rapidly in spite of any remedy other than removal and reclamation. Inspection is commonly made with a straight edge which is placed on top of surface bent rails and a graduated steel wedge is slipped between to determine the average lengths to be sawed off to obtain straight surface relaying rail. Usually the bend extends only a short distance back from the bolt holes, from 12 in. to 24 in. from the rail end. While it is desirable to save all the steel possible, it is worse than useless to saw too little from a rail end,

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as the bend remaining will soon tend to put the bar in bad surface a second time. Rail is usually resawed at some central plant, as at a division point, by means of a friction saw. The crop ends, that is, the defective ends sawed off, are scrapped, the rough edges of the new end sections are smoothed off, the rails are redrilled for track bolts and preferably calipered for wear and marked for relaying so that the contours of the crowns and the gage sides of adjacent rails will match and form smooth riding tracks. The following specifications for relayer rails were adopted in 1920 by the A. R. E. A.:

Classification. Relayer rails shall be classified according to the wear on the side and top of the heads.

(1) Side wear shall be represented by figures, 0 representing no side wear, 1, 2, 3, etc., representing the number of sixteenths of an inch wear on the side of the head at the gage point 5/8 in. below the original top of the rail.

(2) Top wear shall be represented by capital letters, O representing no top wear, A representing 1/32 in., B, 2/32 in., C, 3/32 in., etc., wear, measured at the center of the rail.

(3) If the rail head is worn on both sides the first figure shall represent the side showing the greater wear, the letter the top wear, and the figure following the lesser side wear.

Relayer rails shall also be specified as Bessemer, open hearth, special alloy or process steel.

Main Track Relayer Rails. Class 1, used rails suitable for main track or branch lines. They must be free from all physical defects and shall pass the A. R. E. A. specifications for steel rail in all respects except wear. The surface of the rails of this class must be fairly smooth and must not have flat spots or wheel burns. They must be sawed at the ends, not cut with a chisel. Drilling must be uniform. Chemical analysis or the specifications under which the rails were originally purchased shall be furnished when requested by the purchaser. There shall be full length pieces, 30 or 33 ft. long and not over 10 per cent of shorts varying in lengths by 1 ft. with a minimum length of 22 ft.

Resawing Rails. Class 2. All rails with battered or otherwise defective ends, which if resawed would meet the class 1 requirements shall be accepted and classed as resawed main track relayer rails. In this case 90 per cent of the rails must be of uniform lengths, 27 ft. or more.

Side Track Relayer Rails. Class 3. All used rails suitable for side tracks shall be included in this class. They must not be less than 15 ft. long. Rails too badly out of line or surface to be included in class 1 but straight enough to be easily spiked to line and gage shall be accepted. Drilling must be uniform. Base must be full or uniform width.

Any physical defects, such as broken lower flange, corroded, curved ends, burnt, ends battered, ends down, head flow, line bent, piped, pitted, short, split end, split head, surface bent, twisted, worn under head, shall be specified where they occur and the extent of the defect shall be represented by the use of the terms "slight," "moderate" or "bad."

Scrap Rails

Class 4, Rolling Mill Rails. Rails of standard section not suitable for use as relayer rails. They shall be not less than 6 ft. long and must be free from pipes, split heads and similar defects. Badly twisted rails or bent rails, frogs, switches and guard rails shall not be accepted.

Class 5, Other Scrap Rails. All used rails of any length or condition not meeting the above specifications shall be classed as scrap.

Marking and Shipping. Rails when classified shall be marked by painting the class number in white on the web about 3 ft. from the end. The figure and letter representing the side and top wear shall be painted first, followed by a dash (—) and the class number. No two classes of rails shall be loaded in the same car. Examples: (1) Main track relayer rails having 3/16 in. side wear and 3/32 in. top wear would be classified and marked 3 C-1. (2) Resawed main track relayer rails having 1/4 in. side wear and 3/32 in. top wear would be classified and marked 4 C-2. (3) Side track relayer rails having 1/4 in. side wear and 3/32 in. top wear would be classified and marked 3 D-3. If there are any physical defects, as curved ends, line bent, pitted, etc., they should be so classified and the extent of the defect specified as "slight," "moderate" or "bad."

Rerolled rails, when reclassified, shall be classed separately.

Rerolling rail is usually selected from steel which shows fairly uniform wear throughout the length of the bar, such as flange-worn rail from curves or crown-worn rail from straight track. The object to be attained in rerolling is the production of rails which will be uniform in height and contour on the gage side with a minimum loss in weight per yard and a slight gain instead of a considerable loss in length, as in resawing. Another advantage of rerolling is the additional working of the steel which tends to improve its wearing qualities. A limitation is placed on the tonnage which is rerolled by the cost of transportation of the rail. The rerolling mill has furnaces long enough to heat the entire rail in a horizontal position, and several sets of rolls suitable for the necessary refinishing passes. In this process the rails are pushed by machinery endwise into the furnace, usually six at a time, where they are set up side by side and heated to a moderate red, then removed and passed through two sets of rolls to reduce the section enough to restore its essential symmetry, having regard first to the height of the rail and the shape of the gage side of head, and second, to refitting with standard joints and tie plates. The section is thus reduced by 8 or 9 lb. per yard; an 80-lb. rail being reduced to 72 lb. per yard, while a 33 ft. rail which has been cropped at the ends sometimes finishes 34 ft. long. The various steps subsequent to rerolling, including the cambering, cooling and straightening, generally conform to standard rail mill practice.

Rerolling mill practice involves preliminary classification of rails which can be given a symmetrical section and those so worn on one side as to permit rerolling so as to obtain a proper contour on one side only. After rerolling, the ends of the rails are resawed to insure full sections of metal at the extremities and to eliminate the old bolt holes unless there are three, when the third from the end remains partly filled. Rails which show metal flow or fins are first trimmed of this superfluous metal by passing them along a set of carborundum wheels. All copper bonding plugs and wire are also removed to prevent hot-shortness in the rerolled steel. Cracks and other partly hidden rail defects are disclosed in the rerolling process, so that some dangerous rails are eliminated. Rerolled steel is commonly relaid in main track and when removed from main track it is classed separately from all other relayers.

RAIL, RELAYING. A once-used rail suitable for service in main track. The practice of relaying rail is commonly followed on many roads, particularly in the middle West, where a single system frequently has rails of various sections from 100 lb. or heavier on main lines to 60 lb. on branches. Instead of wearing the heavier rail out in one position it is usually retired from main track when a considerable percentage is worn out, the serviceable bars

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being sorted and graded for further use in main or other tracks. Thus, a rail may be classified and relaid several times during its service life from the main track successively to branch, passing and yard tracks. Although no distinction is commonly made between the classes of relayers for main tracks and the main tracks of branch lines, trunk line steel that is in good condition is frequently removed to branch line main tracks in accordance with a general policy of buying one heavy section of rail only for trunk line service and relaying the lighter rail to improve branch lines with a view to the retirement of the rail of lightest section.

The curve of a relaying rail should not be reversed, nor should steel that has been badly bent and kinked be cold straightened for relaying in any track, as it is unreliable. In selecting relayers, the inspection should exclude any bars about which there is any doubt as to suitability for further main track service. Once-used rails, as they lie along the roadbed after being released from track and the joint bars removed, are preferably sorted, calipered, matched for end heights and gage side contours and marked with white paint with a view to ready selection and loading so that when unloaded for relaying the consecutively match marked ends will be adjacent, and no further sorting necessary.

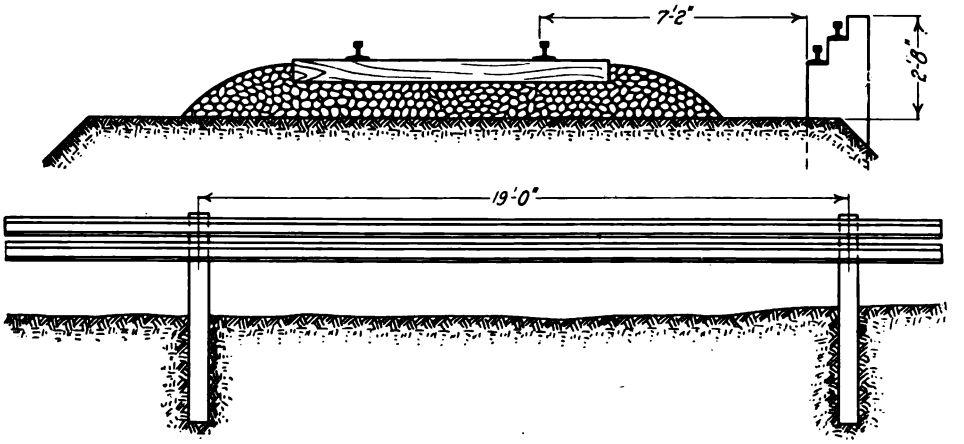
Switch material is likewise sorted, marked and loaded in sets, while broken sets are completed for relaying. See Rail, Relayer. (See Page 712).

RAIL, REROLLING. A once-used rail selected for reheating, reworking between rolls while hot and refinishing, to correct the imperfections of wear with the least reduction in section compatible with a suitable contour for further main track service.

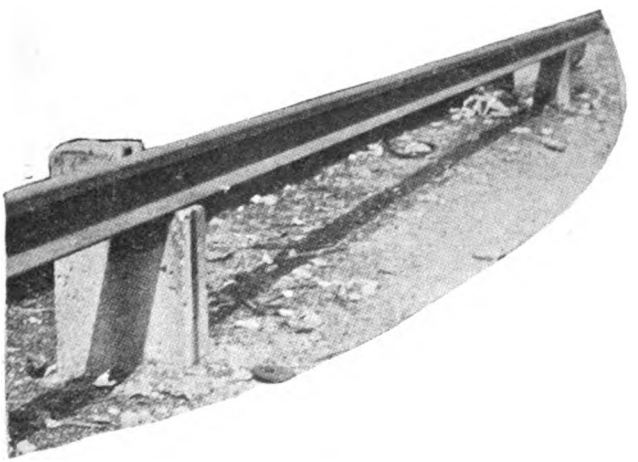
RAIL REST. A supporting device for emergency track repair rails, consisting usually of two or more identical upright 6-ft. posts, slabs or trestles, set 3 ft. in the ground, the outside trestles being about 20 ft. apart so that their line of support is parallel with and not less than 11 ft. from the center line of track. The rest has preferably sufficient surface or surfaces to support two rails.

One type of support is a 6-ft. section of rail drilled through the web near the top for a double U-shaped iron bracket rod of 1-in. diameter designed to support a rail on each side of the post. Other types are upright concrete slabs; or a trestle formed of two ties or posts set close together and supporting a 12-in. long top cross piece.

RAIL, ROLLING IN. A method of regaging track and righting the rail, commonly on curves where the head of the inside rail is sometimes crowded out on account of excess super-elevation of the outside rail or because of unsound ties or inadequate rail-bearing on the ties. In such cases the base of the rail or the outer end of the tie plate, if any, cuts into the fibre of the tie, thus gradually tilting the rail and resulting in a widening of the track gage. The defect is remedied by adzing the ties so as to set the rail upright on its bearing and restore it to gage. In case the super-elevation is too great it is reduced by resurfacing and lifting the inside of the track. Re-adzing is accomplished by removing all the spikes, and the tie plates if any, from a rail, which is then blocked up an inch or more on the ties, while the rail bearings are adzed to new planes parallel to the faces of the ties or inclining inward slightly if it is desired to cant the rail, which is then replaced on the new bearings. By rolling in not more than one or two rails at a time the work usually can be done without delaying trains.



A Typical Timber Rail Rest
Baltimore and Ohio



A Typical Concrete Rail Rest

RAIL SAW. A tool or machine designed to saw steel rails, commonly a circular steel saw of either the toothed or friction type; or a hack saw.

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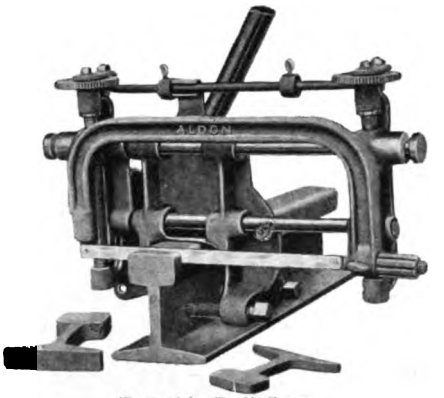
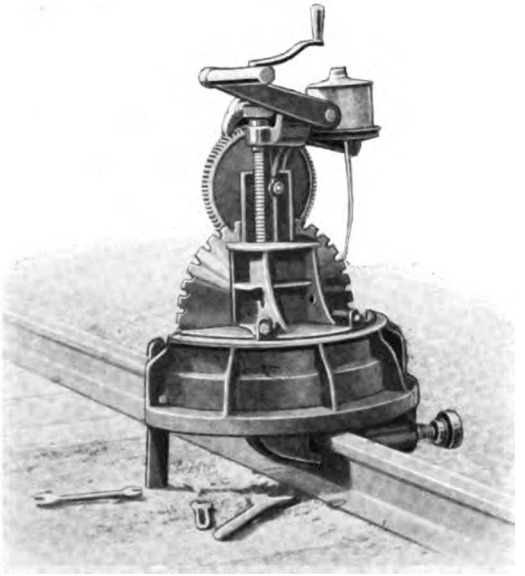
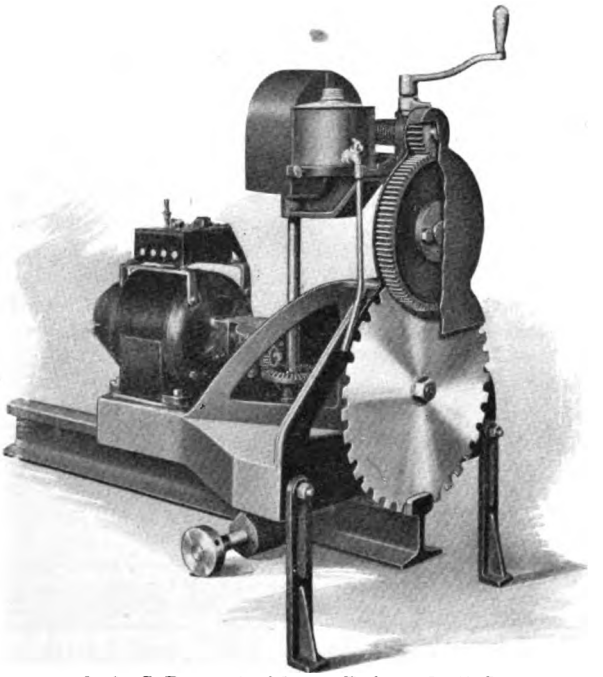
Rail saws are used especially to saw the battered or surface-bent ends from once-used rails as a reclamation measure. Motor-driven shop machines are frequently installed at central points for sawing large tonnages of rails; or a saw and its power unit are mounted on a car and moved from place to place where the rail is concentrated with a view to minimizing its handling and transportation. The toothed circular shop saw is about ⅜ in. thick and 3 ft. to 4 ft. in diameter, with fine milled teeth. It is sometimes made of a low carbon circular plate with high speed tungsten steel teeth inserted around the edge. It operates in a vertical plane, sawing the rails which are handled over a conveyor to the saw table, the adjustments and control of the outfit being similar to those of a circular wood saw. The friction circular saw is smooth edged and designed to melt and cut the metal by means of the friction of the rapidly revolving saw blade against the rail.



Portable Rail Saw
The Track Specialties Co.



Q & C Portable Rail Saw
The Q & C Co.
(See Page 777)



Q & C Portable Motor-Driven Rail Saw
The Q & C Co.
(See Page 777)

Friction Rail Saw Mounted on a Car
The Industrial Works

The small portable machines used by trackmen for emergency rail sawing are toothed circular saws set in vertical frames which may be clamped to the rail and operated by means of attached crank handles which turn the gears; or they may be straight-bladed saws operated by rocker levers. The portable circular saw blade is usually fastened to a sliding sleeve in the vertical frame 30 in. high and is fed automatically into the rail by an adjustable feed screw. The blade is set edgewise on the rail

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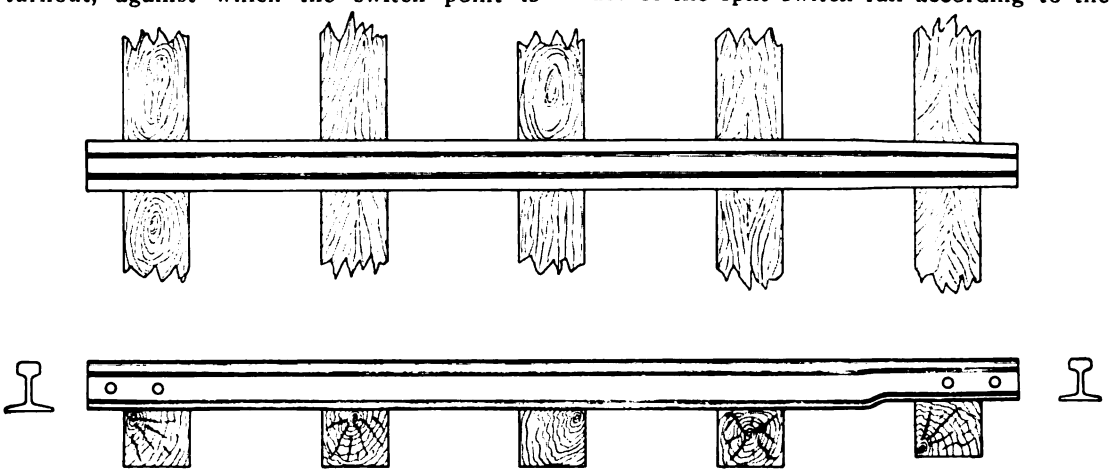
to saw vertically downward through the crown to the base in a true plane, leaving the rail ends smooth and straight.

A hack saw, sometimes used to saw rails, is a stout-framed, thin, straight-bladed saw with fine milled teeth, operated by hand; or it may be used in a portable power machine operated by means of an internal combustion engine or a motor. See Saw, Hack.

RAIL SECTION. The shape of the end of a rail, sheared vertically at right angles to its length. Rail sections are known also by the weights per yard of the rail and by the names of the society or railway responsible for the design.

RAIL, STOCK (Switch). A running rail in one of the two continuous outside diverging lines of rail of a turnout, against which the switch point is thrown to divert traffic. See Turnout. Also Switch. Also Switch, Split.

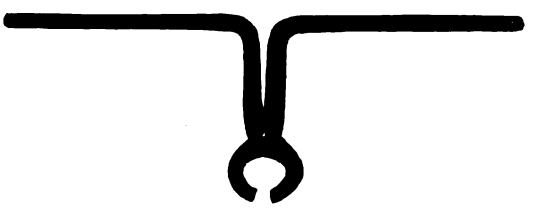


Taper Rail

RAIL, TAPER. A compromise track rail made to fit between and join the ends of two rails of different sections. It is usually a section of the pattern of the heavier rail 8 ft. 3 in. long with a short taper in all surfaces except the gage side of the head to reduce the section to fit the standard joint for the smaller rail. See Rail Joint.

RAIL TONGS. A pair of large steel nippers with long spread handles used to carry rails.

This tool, used by trackmen in setting up rail for track laying, etc., commonly consists of a pair of 1 in. round steel bars, crossed and held with a rivet above the flattened nipper ends which are bent to form ¾ in. by 1½ in. semi-circular, hooked jaws, while about 12 in. above them the shanks are bent oppositely at right angles to form handles 16 in. to 24 in. long which operate scissors-fashion, the jaws clamping firmly around the rail head as the handles are raised. The rail is carried between two lines of 4 or more men, each one holding a handle.



Rail Tongs

REACH ROD (Slip Switch). A long connection rod, usually a pipe from the switch stand to the end bell crank of a slip switch, by means of which the end points are moved from the switch stand located near the center points. See Switch, Slip.

RECEIVING END (of Rail). That end of a rail in a track carrying one-way traffic which comes first in contact with the wheels of rolling stock.

REINFORCING BAR (Frog). A bar or strap bolted or riveted to the outside face of the web of the movable spring wing of a spring rail frog.

REINFORCING BAR, SWITCH RAIL. A filler bar usually of ⅜ in. steel and as high as the web of the split switch rail to which it is riveted throughout the planed length to strengthen the section. Reinforcing bars are used on one or both sides of the split switch rail according to the service required.

REINFORCING RAIL FOR KNUCKLE RAIL (Slip Switch). A planed rail fastened against the outside of the knuckle rail to strengthen it. It is commonly 9 ft. to 10 ft. long with depressed or chamfered ends. See Knuckle Rail (Slip Switch).

RISE (Switch Point Rail). The elevation of a switch point rail introduced with a view to carrying false flanges of wheels over the stock rail.

RIVET, PLATE. A rivet used in fastening a frog to a base plate.

RIVET, POINT. A rivet used in fastening together the point rails of a frog point.

ROAD BED. The finished surface of the roadway. The roadbed is limited to the horizontal top surface between the shoulders of the grade on which the ballast and track are placed.

ROADWAY. That part of the right-of-way of a railway prepared to receive the track.

The minimum width of standard gage, single track, class A railway road bed is 20 ft., as recommended by the A. R. E. A. and as generally adopted in practice on American railways. Excavations are made wide enough to provide also for a roadway drain about 12 in. deep and 4 ft. wide at subgrade on each side between the shoulder of the 20 ft. road bed and the slope of the cut. The width of a double track road bed of this class would be 33 ft. if designed to lay tracks 13 ft. center to center, and the excavations would be 41 ft. wide from slope to

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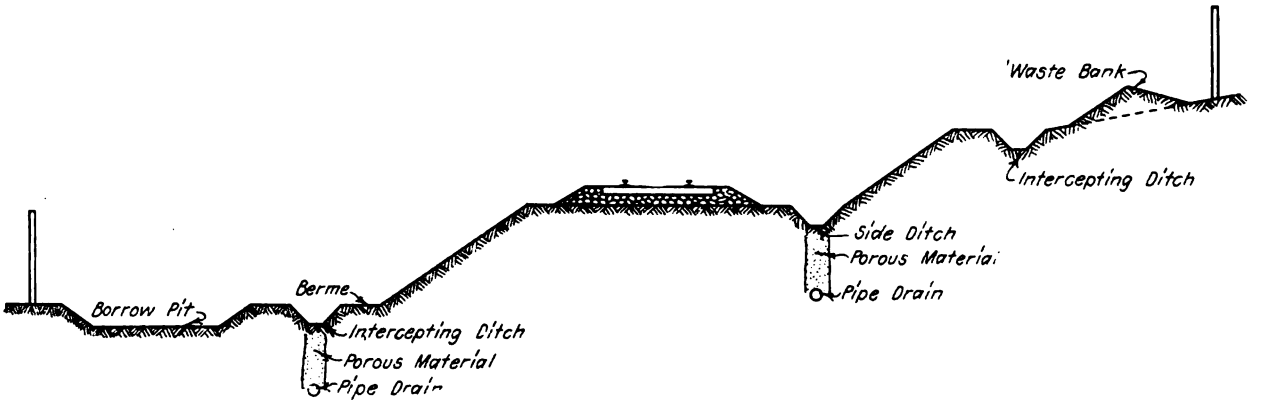
slope at subgrade. The tendency in recent years has been to increase road bed widths which averaged only 14 ft. in embankments and 12 to 14 ft. in excavations 25 years ago when the lighter loads and equipment did not require so much ballast under the ties.

Although the formation of the roadway depends on many contingencies, the grade is usually made of earth, rock, or other material excavated from the nearest cuts or borrow pits, and thrown up in embankments where necessary, to provide a road bed of the proper width and with sufficiently flat slopes to support the ballast, the tracks and the traffic. The



A. R. E. A. Typical Roadway Cross Section

slopes are determined by the character of the materials and local conditions, the usual slopes in earth embankment being 1½ ft. horizontal to 1 ft. vertical, while broken rock generally stands at 1 to 1 in embankment. Although solid rock stand at ½ to 1 or at even steeper slopes in excavation, there is danger of falling stones obstructing the track unless the excavation is wide enough to provide space for lodgment between the bottom of the slope and the road bed. Embankments across swamps are usually made of hard materials even though they may have to be hauled some distance, in order to leave the swampy surface unbroken and thereby afford the best possible support for the embankment; while grubbing in such areas, especially with explosives, is omitted if possible for the same reason.

The materials which form a roadway or grade are usually classified as earth, loose rock and solid rock. All boulders or rock in mass measuring one cubic yard or more and all material which can be best removed by blasting are included in the solid rock class. Stones containing less than one cubic yard, or rocks which can readily be removed without explosives, are classed as loose rock; while all material not included in these two classes is called earth or common excavation, which is the cheapest and most readily moved and therefore the preferable material.

The shrinkage of embankments depends on the character of the material, on the manner of compaction, the formation and on the loads imposed by traffic. Ten per cent is the allowance usually made for shrinkage in earth embankments of moderate height, built on reasonably firm foundation materials.

The preparation of the roadway includes clearing and grubbing, drainage and grading. Explosives are used freely today to uproot trees and to shatter rock and frozen earth, while plows are employed to loosen hard earth. Material is handled with hand shovels, drag scrapers, wheel scrapers, steam shovels, dredges, cranes operating grab buckets, etc. When the distances are long the material is commonly hauled in dump wagons, dump cars, convertible cars or flats. Narrow gage dump cars are propelled by gravity or power, a common method being a stationary hoisting engine controlling the movements of the cars at the end of a cable wound on a friction drum, while hoists are sometimes used to operate belt conveyors to load or waste the materials. Excavations are sloped to maintain temporary drainage during new construction and high embankments are preferably built in horizontal layers of full width and of six feet maximum thickness, in order to compact the materials and minimize the subsequent sloughing off and erosion of slopes, which are built up as plane surfaces, as any concavity can only be temporarily remedied by filling from the top.

When a high embankment is widened or a concave slope is filled out permanently, it is good practice to terrace the slope at intervals of four to six feet vertically to obtain a bond for the additional material, the terraces being preferably canted inward rather than made horizontal. Before ballasting or re-ballasting, it is frequently necessary to fill out eroded or slack slopes in order to provide the proper width of road bed. A re-ballasting program commonly includes some raising of embankments incident to the rehabilitation of regular grade lines and vertical curves at changes of grade. These embankment repairs are ordinarily made with refuse material from the ballast pits.

The weight of a heavy embankment will sometimes depress the ground on which it bears, causing the earthwork to slide or sink. The only precautions that can be taken in such cases are preliminary calculations of the pressure per square foot expected, an analysis of the bearing power of the foundation and such steps as are practicable to drain the ground to eliminate subsidence from pressure of the earthwork. When an embankment sinks or slides it can only be filled and refilled until the movement ceases unless drainage improvement is possible. The first sinking or slide is usually the worst and sometimes the only movement unless there is a water pocket or underground stratum through which water flows, when there may be successive slides or subsidence necessitating extensive

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deep drainage to divert the water and solidify the road bed.

Soundings, test pits and borings are of special value in exploring ground to be excavated, for surface indications are frequently deceptive, such as large boulders and gravel on quicksand or solid rock underlying surface earth, or wet clay beneath a sand overburden. Many disasters in grading are due to insufficient preliminary investigations which, while expensive in first cost, constitute a safeguard that is frequently worth many times the actual cash outlay. Sounding rods, earth augers, diamond drills and well drilling outfits are commonly used for these purposes while shafts are sometimes sunk and excavated by means of small orange-peel buckets, the method and extent of the tests depending on the nature of the material. It is desirable if possible to use tools which will raise cores to show the material encountered at the various depths, for the equipment suitable for excavating is chosen and the safe spread of materials in waste banks is calculated on the basis of the bearing power of soil as indicated by such tests.

A common maintenance drainage problem, the road bed water pocket, frequently has its origin in small depressions in the crown of a new grade which hold water, especially in clay material, which is softened and gradually penetrated by the ballast which admits more moisture as it sinks and enlarges the pocket. The remedy is to cross drain the depression, which is usually excavated and provided at the bottom with a drain extending to the slopes, while fresh hard material replaces the muddy substance removed.

The general requirement of roadway drainage is the provision of sufficient waterways. Those openings which extend through or beneath the road bed frequently carry the run off from extensive drainage areas and are subject to annual high and low water stages and to occasional abnormal floods. Such changes as clearing, cultivating and draining farm land influence the run off, rendering it advisable to provide water openings ample for normal use, but not for extraordinary floods which occur in some cases at intervals of 25 or 50 years. The expense of doubling or trebling the areas for such infrequent emergencies would usually exceed the cost of repairing the flood damage.

It is good practice to locate water openings with a view to leading water directly through the road bed when possible rather than to carry it in ditches along the upstream side of the right-of-way until some convenient opening is found, for there is always danger of it backing in time of flood, overflowing and washing away the grade. Iron or reinforced concrete culvert pipe is commonly used for small culverts, the importance of which is as great in ratio to their cost as the bridges over large streams.

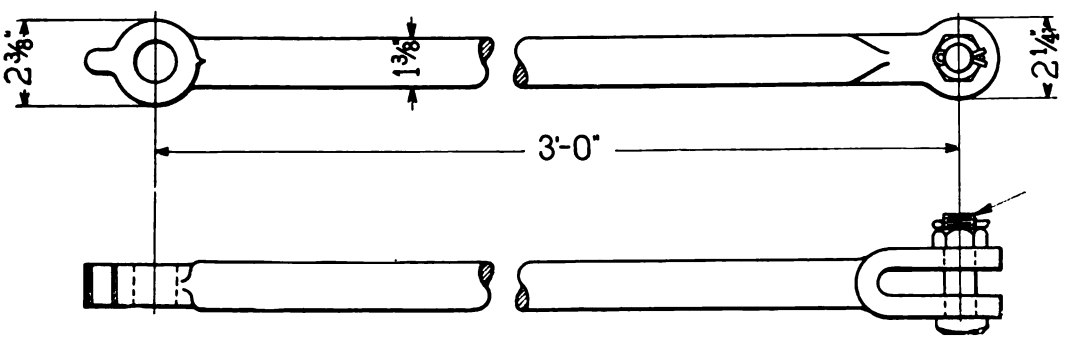
ROCK, LOOSE. Any detached mass of rock which measures more than 1 cu. ft. and less than 1 cu. yd., and all other rock which can be readily removed without blasting.

ROCK, SOLID. Any mass of rock in its natural position which may best be removed by blasting; also detached rocks which measure 1 cu. yd. or more in volume.

ROD, CONNECTING. A horizontal rod, one end of which is designed to be fastened to an extension of the No. 1 switch rod below the base of the running rail, while the other end engages the crank at the bottom of the switch stand spindle. When the spindle is turned, the connecting rod transfers the movement to the switch point rails, causing them to slide sidewise between the stock rails. This movement is so adjusted that the limit of throw brings one switch point close against the gage side of a stock

Drop Connecting Rod
The Morden Frog & Crossing Works

Spring Connecting Rod
The St. Louis Frog & Switch Co.



Plain Connecting Rod
The Pettibone Mulliken Co.

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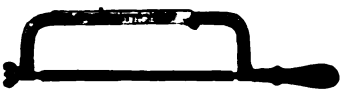
Adjustable Connecting Rod Spring
The Wier Frog Co.

rail while its mate is far enough inside the opposite running rail to clear all passing wheels. See Switch Stand.

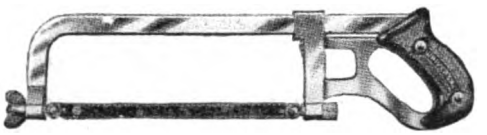
RUNNING RAIL. One of the two parallel main rails on which the wheel treads of rolling stock move.

S

SAW, HACK. A hand operated saw consisting of a frame holding the ends of a thin steel band with a saw-toothed edge. Usually the tool is rectangular, the saw blade forming one of the short sides of the figure while the handle depends from

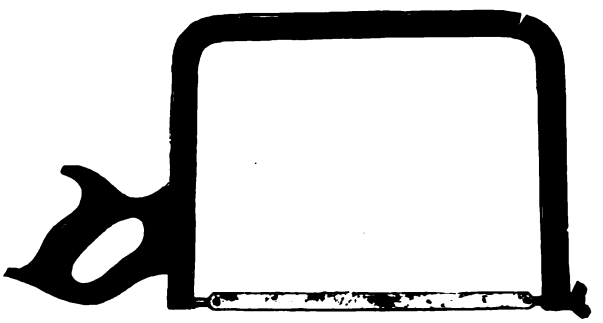


Hack Saw



Hack Saw

Hack Saw Blade

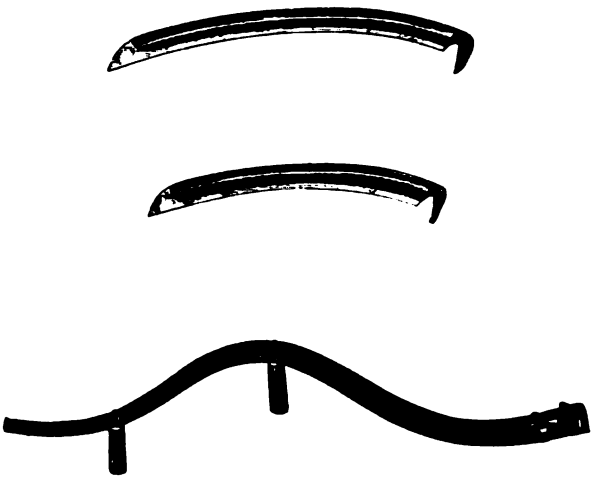


High Hack Saw

the frame directly beneath the blade. Hack saws are used commonly to saw steel and other metal, and sometimes wood. See Saw, Hand. Also Rail Saw.

SCISSORS CROSS-OVER. See Cross-Over, Double.

SCYTHE. An instrument for mowing grass and weeds by hand and composed of a long curved steel blade fastened at right angles to the end of a crooked wooden handle or snath which is furnished with two short handholds. The trackman's scythe

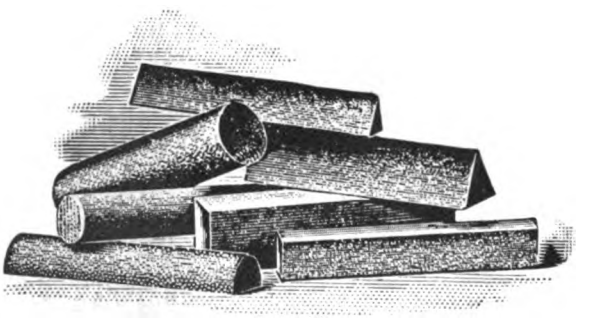


Scythe Blades and Snath

has a slightly curved, sharp pointed, bevel-edged blade 3/32 in. thick, averaging 2 in. wide and about 27 in. long and bent at the back to a hook-like shoulder. At the heel the blade is drawn to a hooked steel stem called a tang, which is turned at right angles to the blade in the plane of the cutting edge, fits in an iron socket on the end of the snath and is held in place by an eye bolt.

SCYTHE STONE. A hand stone for whetting scythe blades.

This sharpener is usually made of fine sandstone or silicious slate and is used to whet the edge of a tool by friction. It is usually oval in section throughout, being about ½ in. thick, 1 in. wide and 10 in. long; but is sometimes tapered symmetrically



Carborundum and Aloxite Sticks
The Carborundum Co.

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Carborundum Niagara Scythe Stone
The Carborundum Co.

from a full rectangular middle section to opposite conical ends.

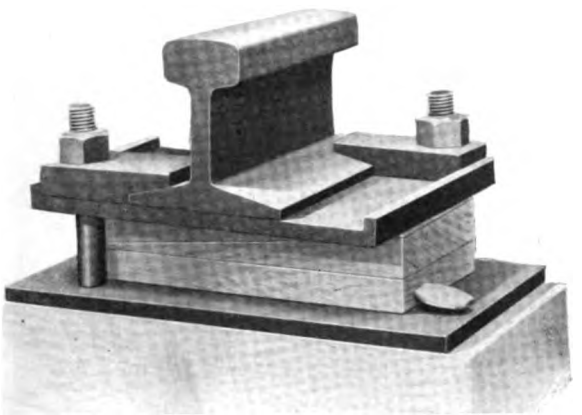
SEPARATOR, ANTI-CREEPER LINK. A square metal washer held between the upper and lower straps of a link by its central bolt to keep their ends separated at the proper distance to permit inserting and bolting the lug between them. See Anti-Creeper Lug (Frog).

SEPARATOR (Guard Rail). A metal block or other device designed to fit the contours of the running rail and the adjacent guard rail and to keep them at the desired distance apart. A guard rail separator is provided with one or more round holes for horizontal bolts. See Flangeway Filler.

SHIM, EXPANSION. A shim designed to separate the ends of abutting rails while track is being laid to make allowance for the expansion of the steel due to changes in temperature. See Shim, Track.

SHIM, FROST. A wooden bearing piece used to surface track which has been heaved unequally by the expansive force of frost in the track foundation. See Shim, Track.

SHIM, TRACK. A separator of metal or wood applied with a view to maintaining the rails in their correct relative positions in the track. The two distinctive types of shims commonly used by trackmen are the expansion shims inserted between rail ends when track is constructed, and the frost shims



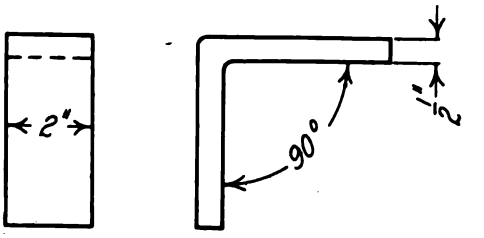
Trasco Adjustable Track Shim
The Track Specialties Co.

placed between the ties and the base of the rail to surface track temporarily which has heaved unevenly on account of frost.

Expansion Shim

The expansion shim is a spacer inserted between the ends of abutting rails while track is being laid to provide allowance for the expansion of the steel due to changes in temperature, and removed as soon as the rails are jointed. Its function is to fix properly the space between the ends of rails to allow changes in their lengths under the extremes of cold in winter and of heat in summer. If the space is too wide, the contracting rails will tend to pull the joints apart in cold weather, while if it is too narrow, the expanding rails will tend to crowd and buckle out of line in hot weather.

The thickness of expansion shims and the allowances they provide are based on the expansion of



Typical Steel Expansion Shim

steel rails, which is taken at 0.0000065 ft. per ft. of rail per deg. F. On this basis 33-ft. rails are laid close without bumping at temperatures of over 100 deg., while a space of 1/16 in. is allowed between the ends of rails for temperatures between 100 deg. and 75 deg., and an additional 1/16 in. for each 25 deg. under the last named temperature, as recommended by the A. R. E. A. in the following table:

Temperature Fahrenheit	Allowance
20 deg. to 0 deg.	5/16 in.
0 deg. to 25 deg.	¼ in.
25 deg. to 50 deg.	3/16 in.
50 deg. to 75 deg.	⅛ in.
75 deg. to 100 deg.	1/16 in.

Over 100 deg., lay rails close without bumping.

Wood shims are sometimes used and left between the rail ends, as when relaying rail, but this practice is approved only under exceptional conditions, as on heavy grades where the shims may be left in place until the track is full-bolted and full-spiked to prevent the rails from creeping down hill. Ordinarily the use of wooden shims is disapproved because they tend to crush and allow the rail ends to crowd too close together.

The ordinary expansion shim is a small section of bar-steel in the form of an angle, about 1 in. wide, with legs 1½ in. long, and of specified thickness as branded. Such a shim is laid on the end of the rail with one leg extending down between adjacent rail heads to keep them apart. A quantity of shims of each thickness likely to be needed (say 1/16, ⅛, and 3/16 in.) should be furnished the foreman in charge of rail laying, for one shim must be inserted at each rail joint, and they must be set ahead as the work progresses, or changed according to variations in temperature, indicated by the track thermometer held with the bulb in contact with the surface of the rail. Expansion shims of this character are usually made in railway shops. They are sometimes branded with the thickness, as 1/16, or with the degrees of temperature between which they are to be used, as 75-100.

Combination metal shims are used on some lines, usually star or cross-shaped castings with legs of the various thicknesses desired. This type is a maintenance device, seldom used elsewhere. Shims

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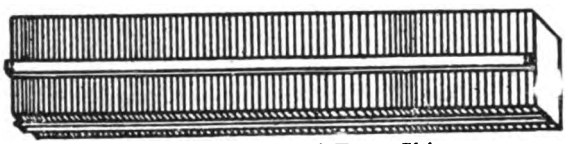
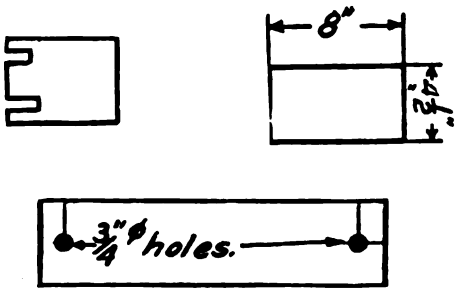
of single thickness are favored where many are used and changed rapidly, as in large track laying projects, because they are cheap, easy to make and handle, and simple of application.

Frost Shim

A frost shim is a bearing piece, usually a thin, rectangular block of hard wood of the width of the rail base and of a length about equal to the width of the face of the tie, intended to be placed under the base of the rail to raise it in low spots to counteract the heaving effect of frost which lifts the moist ground supporting some cross ties more than the dryer ground which supports others. The shim is slipped under the rail on top of the tie plate by loosening the track spikes enough to permit it to be inserted and then redriving them. Such a shim requires no extra spikes as it is held in place just as the base of the rail and the tie plate between which it fits.



Bundle of Assorted Frost Shims



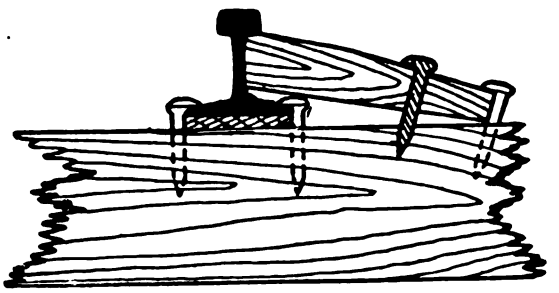
Slotted and Plain Frost Shims

If the shim is 1 in. to 2 in. thick, it is advisable to brace the rail, and sometimes to use special long shimming spikes. Track spikes 6 in. long with the heads projecting 1¾ in. or more out of the tie cannot be depended on to hold rails to gage; therefore thorough bracing is necessary. A special wooden brace is commonly used to brace high shimmed rails. This brace is about 15 in. long and the head fits against the web under the rail head, while its outside end is spiked on the tie. These special braces are used because the raising of the rail on the shim destroys the fit of the ordinary rail brace unless it can be placed on the shim, which is only feasible when the shim extends several inches outside the rail. In extreme cases of heaving, thick boards 8 ft. long or even ties are placed on the track ties to bring the rails to surface. Shims more than 2 in. thick are preferably made as wide as the tie and 15 to 18 in. long. They are bored for track spikes and are laid lengthwise of the tie under the tie plates with a spike through each end to hold them down, independent of the spikes which hold the rail, for which other holes are bored. Sometimes thick shims are bored only for the rail spikes. When these holes are wider apart than the width of the base of the rail, the shims have to be set diagonally across the tie, but this is not considered good practice, for the best possible rail bearing should be obtained, of area equal to or greater than that of the rail on the tie or tie plate supporting the rail.

Frost shims are ordinarily manufactured in a wood working mill where the hardwood logs are sawed into blocks which are cut into shims of various thicknesses as ordered, ranging from ¼ in. to 1 in., with shingle or veneer knives. These shims are of the same width as the rail base and as long as the width of the face of the tie, or tie plate, and are tightly baled in single tiers or bundles of 75 to 100 pieces of assorted thicknesses. They should be made of sound, tough wood and should be seasoned in the bundle to prevent warping. Shims thinner than ¼ in. tend to crush and spit too easily to be serviceable.

Track shimmed high is likely to become unsafe when the snow is deep, making it hard to detect loose braces. The best practice, therefore, is to keep the shimming to the minimum, especially in early winter, and to restrict the speed of trains if necessary at the worst spots.

When track heaves, short portions usually rise in abrupt undulations, sometimes within a few feet of each other or further apart at irregular intervals. Frequently an isolated hummock appears, sometimes affecting one rail only. Shims are placed between adjacent undulations, or runoffs are made on each side of a hummock to lengthen and ease the vertical curves. If only one rail heaves, the opposite rail must be shimmed to the correct relative level. Track that has heaved will usually continue to rise as the frost deepens and will subside as the frost leaves the ground. The time of greatest danger to shimmed track is in spring when the shims are highest and inequalities in surface alter daily, due to alternate freezing and thawing. Shims must be changed accordingly to keep the track in reasonably good temporary surface. As soon as the frost is



High Shimmed Rail with Timber Brace

out of the ground, shims should be removed and the track surfaced with ballast.

In the spring, track which has heaved during the winter should be drained to prevent a recurrence of the trouble. Slight heaving may be due to foul or porous ballast which holds the moisture. More often the ballast rests on an undrained foundation. Some such spots are short, shallow depressions in the crown of the road bed. Larger areas are frequently of loose loam or sand surrounded by clay

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or some other dense material which holds the water under the track.

Some winter seasons are so severe that spots which do not ordinarily heave, give trouble because the frost strikes deeper than usual. Annual records showing locations of shimming are invaluable in determining drainage projects. Spots that heave only during the most severe winters usually do not justify special drainage on account of heaving alone.

SHORT POINT RAIL. The shorter of the two pieces of rail which form the frog point. The short point rail is planed and notched into the side of the long point rail a few inches back of the actual point. See Long Point Rail. Also Frog.

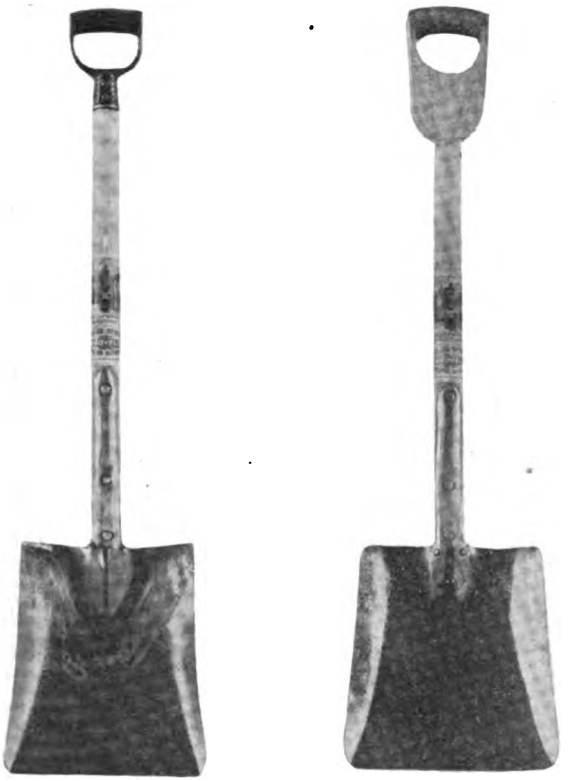
SHOULDER WASHER. See Head Lock.

SHOVEL. A tool used for digging, lifting and throwing earth, etc., consisting of a thin pressed steel blade with upturned edges, cast with or riveted to a top ferrule or handle socket, which is bent back from the plane of the blade and designed to hold a wooden handle which, when not over 3 ft. long, usually terminates in a D-shaped or V-shaped hand-hold.

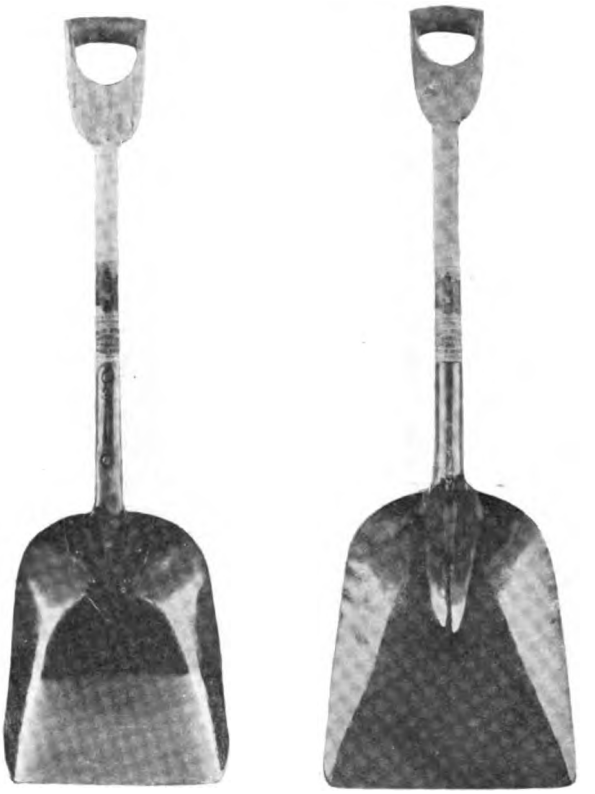
The blade is concavely pressed so as to hold the bulk of the load close to the handle, thus reducing the leverage while the ferrule and handle are so curved that the operator can dig, lift and throw with minimum waste, full shovel loads of material with the least exertion. Shovel handles vary in length from 2 ft. to 6 in. to 5 ft. or longer according to the use for which the tool is designed. Special high carbon steel is commonly used in the blades to give them the hardness and toughness necessary to withstand general wear and tear, while the points are sometimes specially tempered to prevent the working edges from turning.

Shovel ferrules or handle sockets are cylindrical or slightly conical in shape, consisting either of front and back steel socket straps or cylindrical sockets about 10 in. long. The types common to railway maintenance are the square point, round point, scoop and snow shovels. The first two types are either short or long handled, while the scoop, being larger, is usually short handled, and the snow shovel used for lighter loads, is commonly long handled.

Round Point Track Shovel



Two Styles of Square Point Track Shovels
(See Pages 708 and 820)



Large Narrow Shoulder Scoop Shovel
Small Wide Shoulder Scoop Shovel
(See Pages 708 and 820)

SHOVEL (Round Pointed). A shovel for cutting, digging, lifting and throwing earth, etc.

This tool differs from the square pointed shovel in that its shield-shaped round pointed blade is slightly and symmetrically concave and does not turn up at the sides, thus making it more suitable for cutting hard ground. The blade, usually 11 in. wide at the shoulder and 14 in. long, is fastened to a wooden handle by a ferrule or handle socket which is cast with or riveted to the blade. This tool is commonly equipped either with a short wooden handle about 27 in. long, terminating in

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a D-shaped hand-hold, or a pole handle 4 ft. or more in length, the latter style being especially adaptable to digging deep holes and trenches, where the long handle is convenient for casting heavy material to a distance.

SHOVEL (Square Pointed). A shovel used to tamp ballast, to dig, lift and throw material, etc. This flat-bottomed, square-shouldered, short-handled tool is the shovel generally used by trackmen in maintenance work. The stout steel blade about 12 in. long and 10 in. wide is welded at the top to

Long Handled Round Pointed Shovel
Long Handled Square Pointed Snow Shovel
(See Pages 708 and 820)

the end of a ferrule or handle socket in which a short wooden handle is riveted. The sides of the blade are upturned at an angle of about 75 deg. with the face, thus forming a shallow retainer which is deepest near the shoulder of the shovel. The blade is preferably made of hardened steel that will best withstand shoveling and tamping stone, gravel, etc. The wooden handle frequently made of white ash is about 27 in. long and terminates in a D-shaped hand-hold, usually of wood but sometimes of malleable iron.

SHOVEL, SNOW. A flat bottomed, straight-edged, wide-bladed, lightly built shovel used for clearing snow from tracks, platforms, etc. While other styles of shovels are sometimes used for this work, snow is ordinarily light enough to be more readily handled with this large blade at the end of a long pole handle which affords the operator opportunity to work without much stooping. Short snow shovels differ from this type only in the length and hand-hold of the handle.

SHOVEL (Scoop). A large, wide-mouthed, short handled shovel for handling light, bulky materials. This type of shovel has a square-edged, flat-bottom blade, with rounded shoulders and high upturned edges which form a deep retainer of capacity exceeding that of any other type. It is designed for the ready handling of loosely piled, bulky materials such as coal, cinders, etc. The blade, usually from 12 to 15 in. wide and from 16 to 20 in. long, is commonly cast with or riveted to a ferrule or handle socket, the scoop being about 3 ft. 8 in. long from the top of the D-shaped wooden hand-hold to the end of the blade.

SHRINKAGE (Roadway). The contraction of embankments due to the compacting of the material. The particles of earth or stone which a freshly formed embankment consists retain to some extent the forms in which they are broken from the mass when excavated and there are spaces between the edges of these individual pieces of material. Gradually the particles lose their shapes through disintegration and under pressure of traffic, tending to reform into a solid mass, filling and eliminating the interstices and thereby occupying less aggregate space. This process affects every portion of the embankment and results in a sinking of all the surfaces, including the slopes as well as the top, for which allowances are commonly made in construction.

Shrinkage in embankments and swelling of excavations depend on the character and handling of the material moved. Solid rock removed from an excavation will swell 25 per cent or more when placed in embankment, while sand and clay mixed will shrink 10 per cent, these percentages representing conservative averages on which to base calculations of the probable shrinkage of other materials.

The A. R. E. A. has established the following allowances to be made in new earth embankments for shrinkage in both height and width:

For black dirt, trestle filling: 15 per cent.
For black dirt, raising under traffic: 5 per cent.
For clay, trestle filling: 10 per cent.
For clay, raising under traffic: 5 per cent.
For sand, trestle filling: 6 per cent.
For sand, raising under traffic: 5 per cent.

SIDE PLANING (Switch Point). The cut made along the side of the head of a rail to form a split switch point rail, and extending from the point back to the place of divergence of the heads of the switch point rail and the stock rail.

SIGN. A marker consisting of a board, a metal plate, a post or a combination of the foregoing, installed on or near railway property for the information of employees or the public through the

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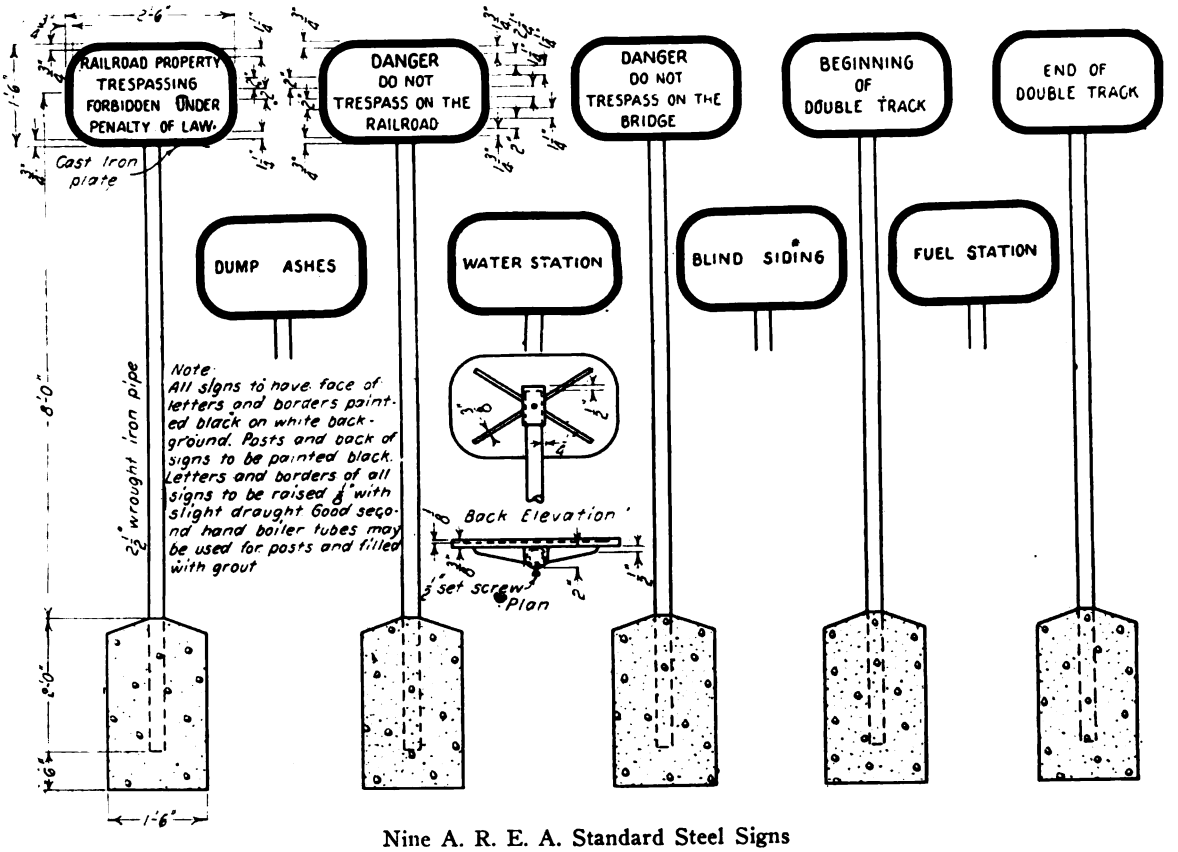
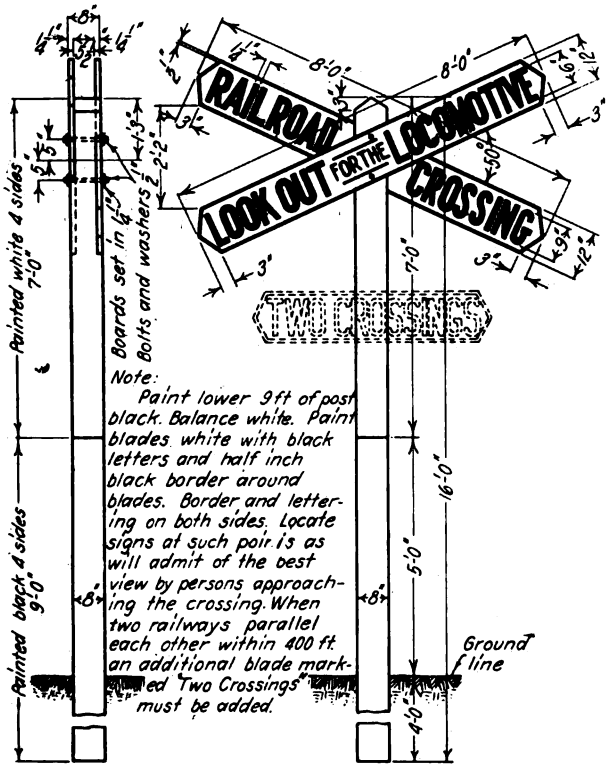
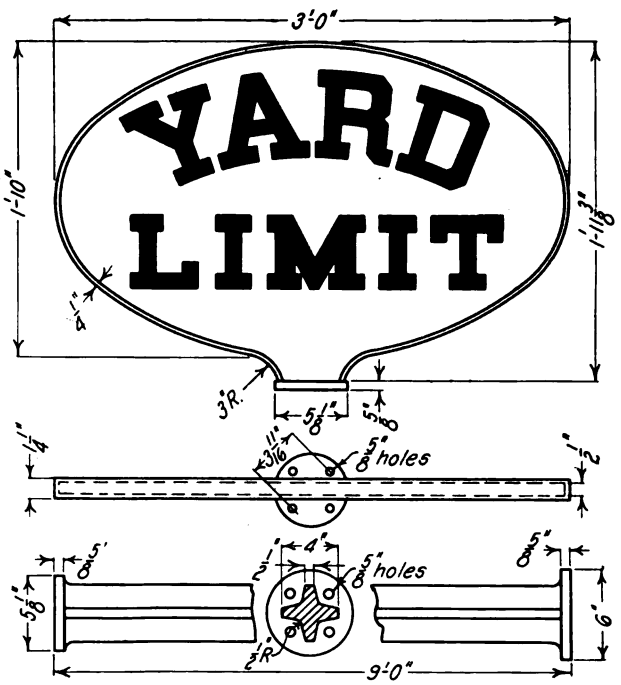


Nine A. R. E. A. Standard Steel Signs



A. R. E. A. Standard Highway Grade Crossing Sign



Steel Yard Limit Sign
Southern Ry.

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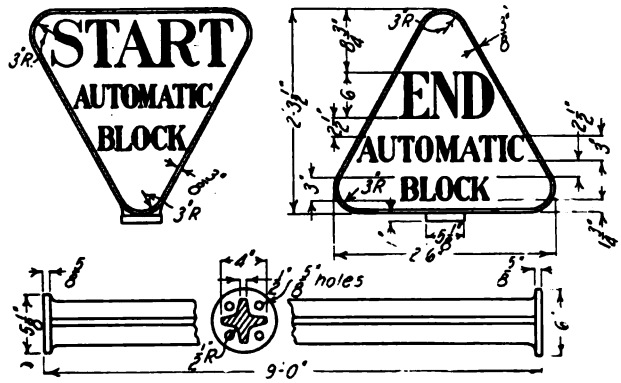
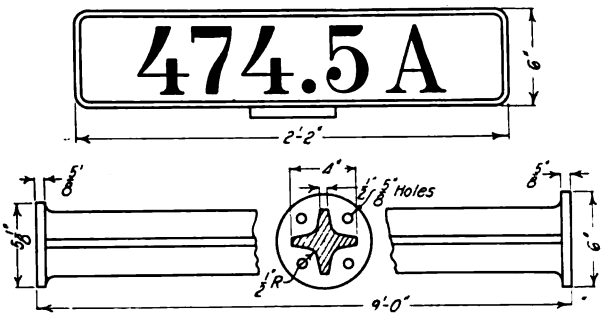
medium of its shape, contour, inscription or the design upon its surface.

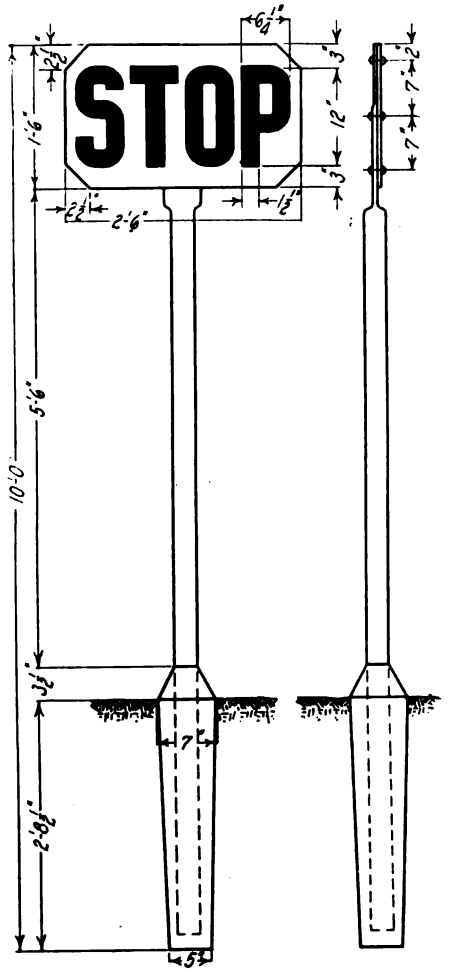
Based on their function or use, roadway signs may be divided into two general classes: (1) those designed for the information and guidance of the public, such as highway crossing and trespass signs, and (2) those which impart instructions and guidance to employees, such as whistle posts, mile posts, clearance posts, bridge and trestle numbers, section numbers, railway crossing signs, etc. The construction and location of signs of the first class are commonly fixed by laws or by rulings of the public utility and railway commissions, which specify the size, character of inscription, location and number of signs to be used. The laws governing signs of the second class are commonly expressed by implication only, the installation of whistle posts, ring posts, etc., being made necessary by regulations such as those requiring the blowing of the whistle or ringing the bell of a locomotive when approaching highway crossings.



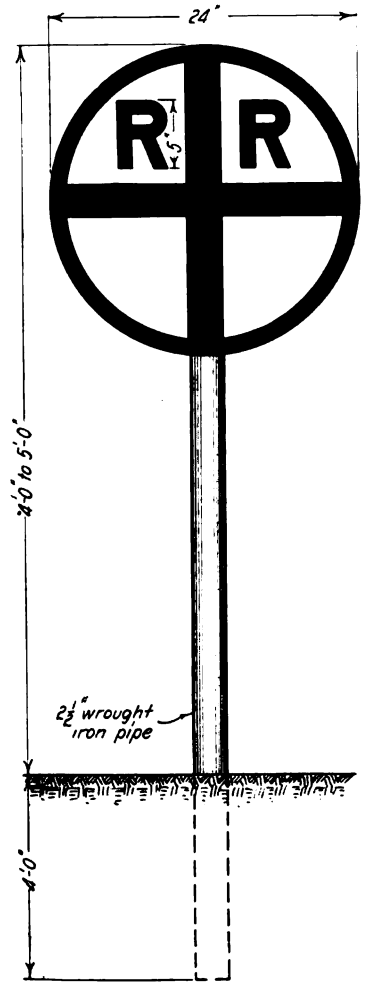
Steel Automatic Block Signs
Southern Ry.



Standard Steel Bridge Sign
Southern Ry.



Standard Iron Stop Sign
C., B. & Q. R. R.



Enameled Steel Highway Crossing Approach Sign
A. R. A.

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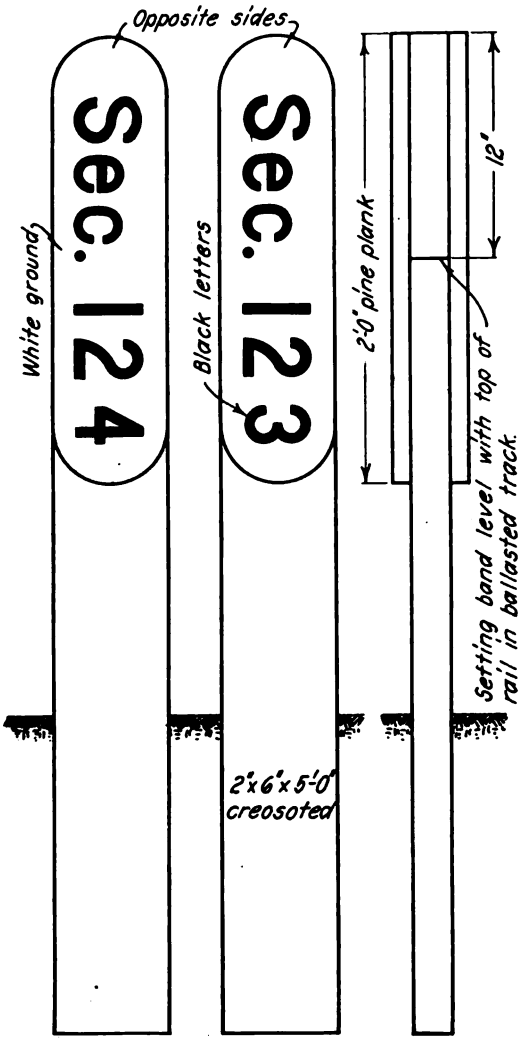
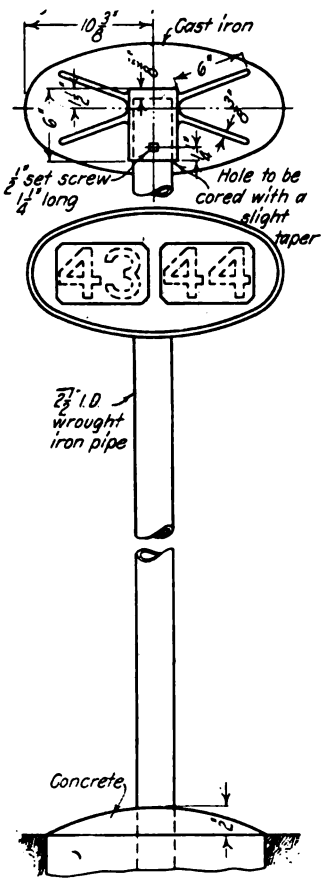
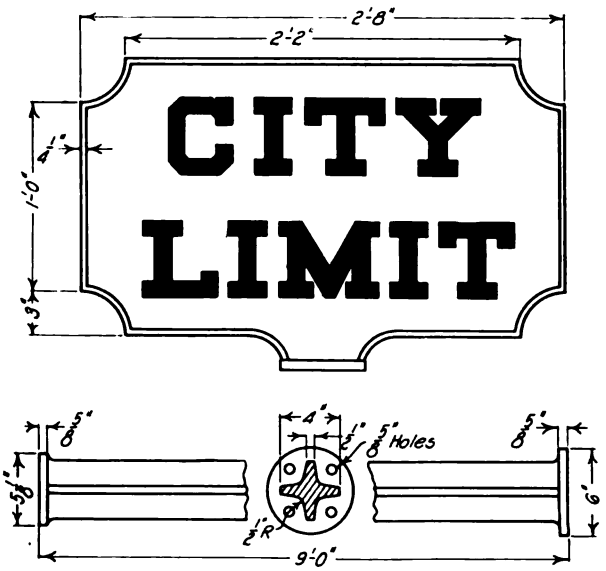


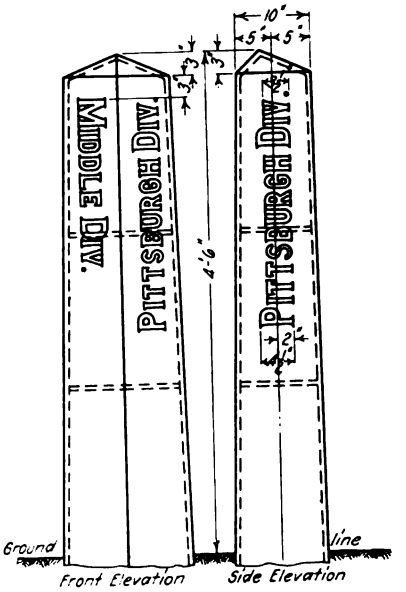
Standard Wood Section Post
Atchison, Topeka & Santa Fe Ry.



Steel Section Post
Southern Ry.



Steel City Limit Sign
Southern Ry.



Division Post
Pennsylvania R. R.

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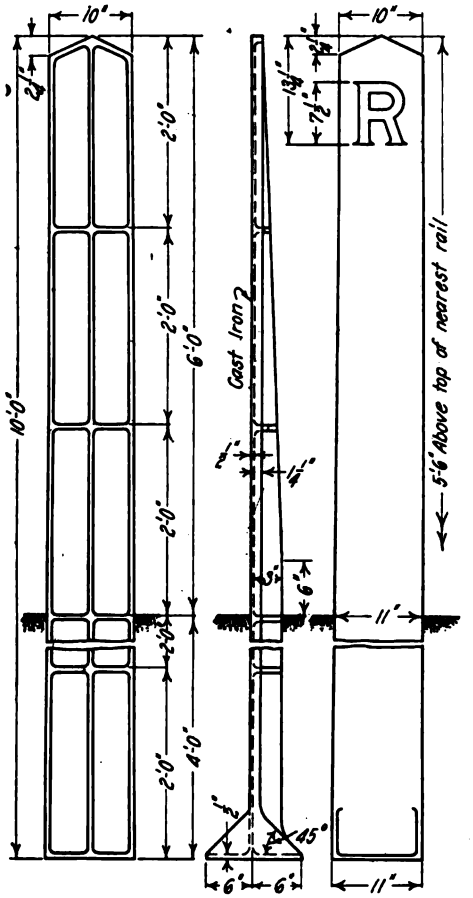
The type of sign most commonly used consists of a board or a metal plate mounted on a building, a bridge, etc., or on a post. Such markers are generally rectangular, although they may be of circular, octagonal and other miscellaneous shapes; their size depends upon the purpose for which they are intended, the length of the inscription and the distance at which they must be visible. The information which the sign is to convey is either painted, carved or cast on the surface, or formed by perforations through the face, the necessary contrast between the letters, figures or designs and the background being usually secured by the use of different colors. It is common practice to paint the background white and the inscription and border black, this combination having been found effective both in arresting the attention of those to whom it is directed and in affording a high degree of visibility. This effect has been produced in another type of the same general character and purpose by punching the letters out of a metal sheet, the action of the light when seen through the punched-out parts and against a dark-colored background giving the desired contrast, although they cannot easily be read from the rear. The work of painting is entirely eliminated in a third type of sign by the backing of enamel on a metal foundation, the inscription being formed at the time of enameling.

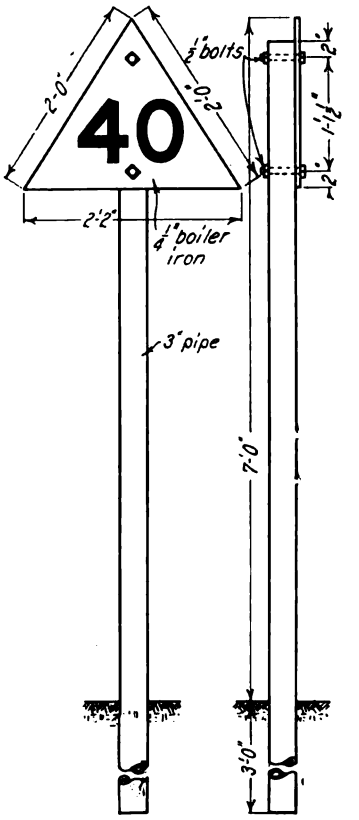
A second type of sign in common use includes posts and monuments constructed from wood, metal, concrete, stone or similar materials in varying shapes and sizes. The inscription or design is generally much shorter or more condensed since its use is generally confined to the guidance of employees. The necessary color contrast is secured by painting the top of the sign carrying the inscription a distinctive color with the desired characters painted on that, although in many installations a particular color, a post of a particular shape or a combination of the two is used to denote a certain condition or the need of a certain action, thus dispensing with the need of an inscription. Where their use is restricted entirely to the guidance of employees and there is no liability of confusion, a variety of designs, types or colors may be used that will answer all the requirements of larger and more expensive signs.

Signs of the first class, that is, those that are not in themselves posts or monuments, are mounted on or attached to buildings, bridges, telephone and telegraph poles, etc., or to posts set for that purpose alone. These posts may be timbers of varying cross-section, reinforced concrete posts, metal standards especially designed for that purpose, or frequently old boiler flues filled with grout; concrete or stone foundations generally being used with the last two kinds. Where the posts are of wood it is important that they be given some form of preservative treatment. It is commonly considered good practice either to treat the lower half of the post with a preservative or to bolt the post to a section of treated timber which projects two or three feet above the ground. In fastening the sign



Steel Whistle Post
Pennsylvania R. R.

Speed Limit Sign



Standard Speed Limit Post
B. & O.

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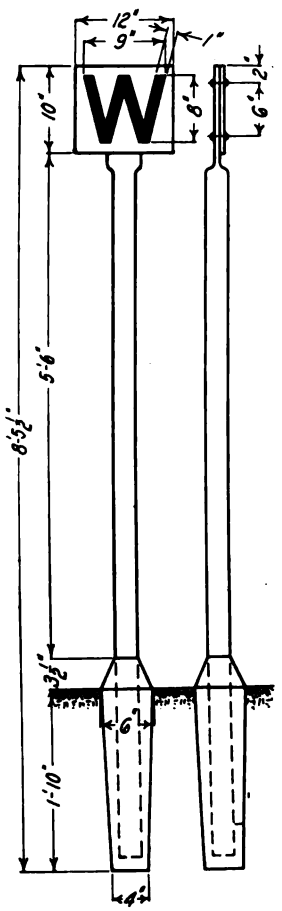
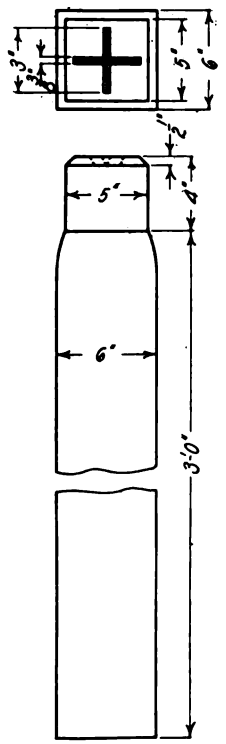
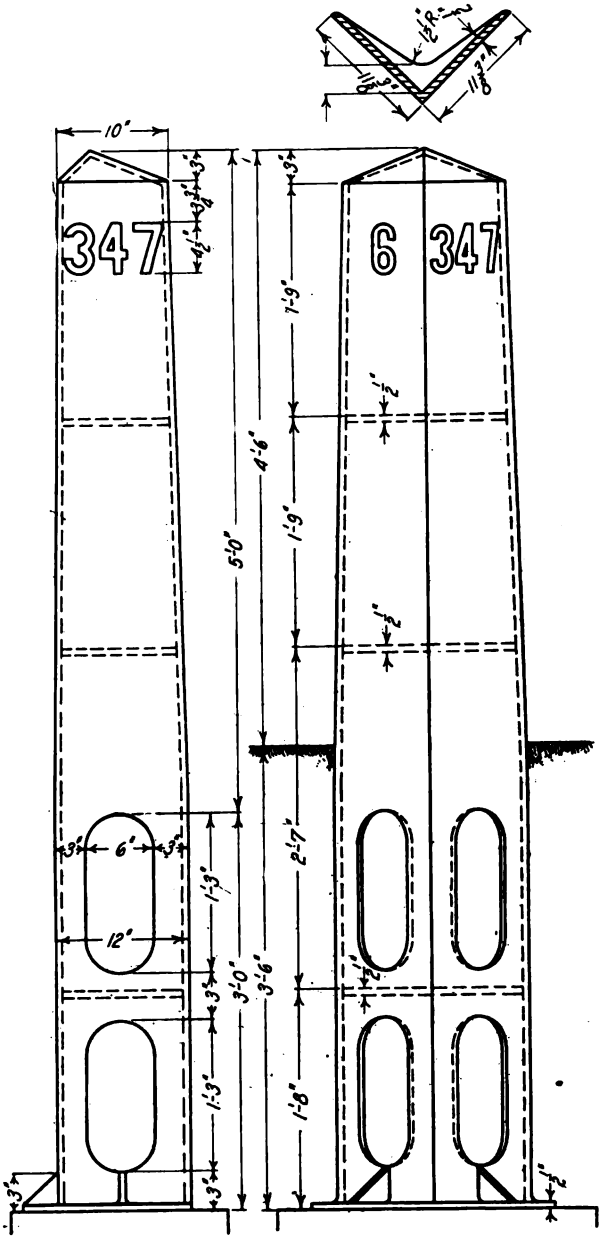


Steel Whistle Post
C., B. & Q. R. R.

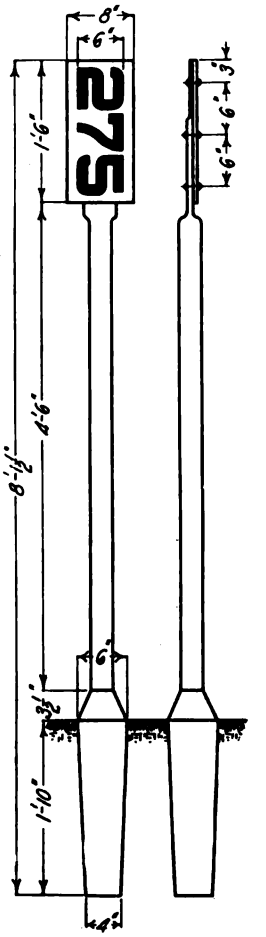


Property Post
Pennsylvania R. R.



Cast Iron Mile Post
Pennsylvania R. R.

Wooden Whistle Post



Standard Iron Mile Post
C., B. & Q. R. R.

Mileage Sign on
Telegraph Pole

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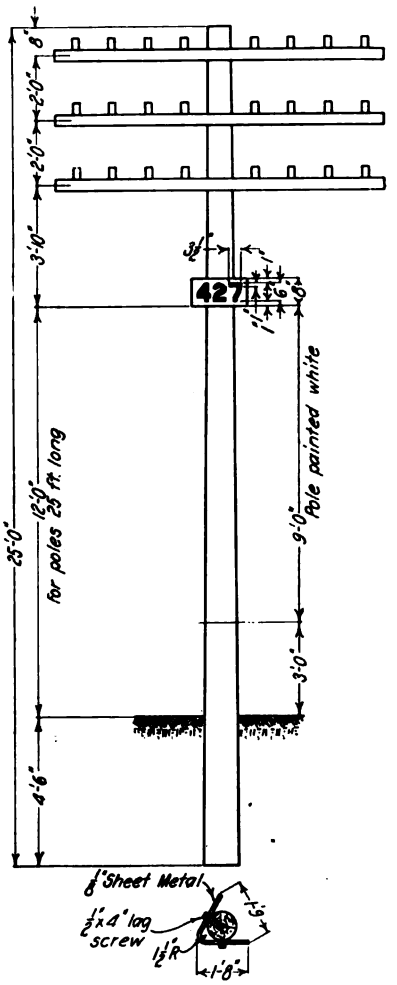
to a building or post, lag screws are used in wood, with bolts or clamps in metal or concrete.

In placing signs along a railway right-of-way, in yards, terminals and station grounds, the best practice limits the height of the bottom of the sign to from 6 ft. to 12 ft. above the base of the rail, with a minimum horizontal clearance of 8 ft. from the nearest rail. Any greater or less height in the first case or a decrease in the minimum distance given in



Steel Mileage Sign on Telegraph Pole
Atchison, Topeka & Santa Fe R. R.

the second will result in reduced effectiveness of the sign or in an increased hazard to trainmen or other employees. Where multiple tracks, switches, etc., interfere with the above arrangement, the sign must be placed according to the best judgment of the man in charge, care being taken that its meaning cannot be misconstrued on account of its location and that it does not tend to form an obstruction. In all installations close attention should be paid to the selection of the location for the sign in order to secure the necessary degree of prominence and visibility. It is also important that the number of signs on a railway be kept to the minimum as the unnecessary use of them tends to destroy their effectiveness.

Other essential features of a sign are durability, neatness, simplicity, and concise inscription, the wording preferably being in the form of a plain, direct order rather than in the form of a threat or a caution. Where danger is the keynote of the sign the hazard should be stated, for where danger implied is not specified the law does not consider it indicated. A sign showing the probable danger to be encountered such as "DANGER! BLASTING! KEEP OUT" is more effective in producing results than a sign in the same locality reading "DANGER! KEEP OUT."

SIGN, AUTOMATIC BLOCK. A sign placed on a railway right-of-way near the beginning or end of a stretch of automatic signals to indicate the limits of such a system for the guidance of trainmen, etc.

Automatic block signs may be divided into two classes: (1) Start signs and (2) End signs which classes differ only in the inscriptions painted on them and in their locations in regard to the automatic signals. In general, they are constructed of wood boards or metal plates mounted at right angles to the track and from 6 ft. to 7 ft. above the base of rail on posts set from 11 ft. to 12 ft. from the center of the track. The letters and border are painted black on a white background, the post being painted white from the top to within about 12 in. of the ground, and the remainder black. A sign of the first class has an inscription similar to "START! AUTOMATIC BLOCK" and is placed on the right hand side of the track near the first automatic signal encountered when traveling in either direction; a sign of the second class bears an inscription such as "END! AUTOMATIC BLOCK" and is placed on the right of the last insulated rail joint passed over by a train moving in either direction.

SIGN, BRIDGE. A marker placed on or near a railway bridge or trestle upon which there has been painted an inscription for the purpose of establishing the identity of the structure. Bridge signs, or as they are commonly called, bridge and trestle numbers, are usually constructed from wood or metal painted white with the letters or figures or both painted in black on both sides. They generally consist of posts or of boards or plates mounted on posts set from 4 ft. to 6 ft. above the base of rail with the end of the sign not less than 9 ft. from the center of the track. Only one sign is used for single and double track bridges up to approximately 100 ft. in length, while two are used for bridges over 100 ft. and for all bridges having more than two tracks. Where bridge members project above the base of rail, it is common practice to paint the inscription on each end of the bridges in white on a black background or the opposite, at a height of from 5 ft. to 9 ft. above the base of rail. Bridges of this class carrying two or more tracks are numbered in most instances, on both sides of the roadway. Where rivers are crossed it is also a common practice to give the name of the river as a part of the inscription.

SIGN, BRIDGE TRESPASS. A sign placed at the end of a bridge to warn the public against the danger of attempting to cross the structure and that it is private property on which trespassing is forbidden. This sign, generally of wood or metal, is similar in form to a trespass sign, and is mounted on a wood or metal post set about 10 ft. from the center of the track and as near to the end of the bridge as conditions will permit. In the majority of installations, the inscription reads about as follows: "CAUTION! DO NOT WALK OR TRESPASS ON THIS BRIDGE." See Sign, Trespass.

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SIGN, CITY LIMIT. A marker placed on a railway right-of-way at the corporate limits of a town or city for the guidance of trainmen or other employees. It is generally constructed of wood or metal and mounted on a wood, metal or concrete post at a minimum distance of 11 ft. from the center of the track and from 5 ft. to 7 ft. above the base of the rail. In the majority of cases, the inscription consists of the two words "CITY LIMIT" and a border painted in black on a white background.

SIGN, CLEARANCE. A post or other marker set on a railway right-of-way for the guidance of railway employees, showing by its location or inscription the minimum clear distance allowable from the center line of the track to fixed structures such as buildings, etc., or the points beyond which it is unsafe to place cars on converging tracks, especially at passing track and yard turnouts.

Clearance signs are generally wood, metal or concrete posts; although in some instances they are sign boards or signs on posts the latter being used principally at approaches to railway and highway overcrossings and at other places where the clearance is limited. Such signs are usually placed on the engineman's side of the track 11 ft. from the center line of the track and from 6 to 8 ft. above the top of rail, the face of the sign or post being set at right angles to the line of the track, painted on a white ground with black letters.

Those which limit the placing of cars on converging tracks are commonly 4 in. by 4 in. posts, only the white painted tops of which show above the ballast midway between the tracks to be protected. Sometimes a beveled board painted white is nailed flat on a tie in the middle of the track or a plank similarly painted is laid parallel with and extends between the ends of the ties of the adjacent converging tracks, or a sign on a post is placed alongside the outside track, the object being to designate the clearance in such a manner as to avoid danger of employees stumbling against the marker.

SIGN, CROSSING APPROACH. A sign placed on the right hand side of a public highway leading toward a railway track and not less than 300 ft. from their intersection at grade, to warn persons traveling on the highway that they are approaching a railway grade crossing.

The standard type of the A. R. E. A. that has been adopted by law in a large number of states is a circular metal disk with the letters R. R. enamelled in black on a white background, the disc being mounted about 5 ft. from the ground on a metal post set as near as possible to the actual edge of the road. This location and the height of the sign have been found to be effective both day and night as it is well within the focus of automobile headlights.

The general requirements of the A. R. A. for the construction and painting of crossing approach signs are as follows:

The sign should be constructed from a circular metal disc 24-in. in diameter, to be painted white with two lines 2½ in. wide and 1-in. border around the sign; the letters R. R. to be in the upper quadrant formed by the cross lines, one letter in each quadrant, measuring 5 in. high by 3¾ in. wide and of 1 in. stroke; all crosslines, borders and letters to be painted black. The sign should be mounted on a post made from 2½ in. wrought iron pipe or good second hand boiler tube filled with grout, painted black and sunk about 3 ft. 6 in. in the ground at a distance of not less than 300 ft. from the intersection of a public road and a railway track.

SIGN, DERAIL. A marker indicating the location of a derailing device, usually a small steel target or sign or a wooden post, bearing the letters D. R. or the word Derail painted in black on a white background.

The target sign, attached to a spindle which moves with the derailing device, indicates by its position whether the derail is open or closed. The steel sign is usually rectangular or circular with a turned edge serving as a border, and mounted on a pointed ⅜ in. round steel rod 3 ft. long, adaptable for use in connection with portable derails used on repair tracks, etc. The wooden post is ordinarily a 3 in. by 10 in. timber 4 ft. long above ground set 3 ft. in the ground opposite the head block of the track on which the derail is located, or sometimes directly opposite the derail. The inscription D. R. is painted in black letters 4 in. high near the top of the post.

SIGN, DOUBLE TRACK. A sign placed on a railway right-of-way near the beginning or end of a stretch of double track to indicate its limit for the guidance of trainmen and other employees.

Double track signs may be divided into two classes; first, those indicating where the double track commences and second, those indicating the end, the two classes differing only in their locations and the inscriptions painted on them. In general, they are made of wooden boards or metal plates mounted at right angles to the line of the track on posts extending about 6 ft. out of the ground, set 12 ft. from the center line of the track they govern and from 300 to 400 ft. from the head block marking the actual beginning or termination of the double track. The letters and borders are usually painted black on a white background, the post being painted white from the top to within above 12 in. of the ground and the remainder black. A sign of the first class has an inscription similar to "DOUBLE TRACK BEGINS" and is placed on the right hand side of the track beyond the head block marking the beginning of double track; a sign of the second class bears an inscription similar to "DOUBLE TRACK ENDS" and is placed on the right hand side of the double track opposite the turnout which marks the end. The general requirements of the A. R. E. A. for signs of this class are that they be made similar to the standard trespass sign. See Sign, Trespass.

SIGN, ENAMELED IRON. A sign of sheet steel into which several coats of enamel have been successively burned in order to make the lettering and

Enameled Steel Sign
The Ingram-Richardson Manufacturing Co.
(See Page 713)

background over the entire surface equally durable and weather proof. Enameled signs are made in various sizes and are frequently used for advance

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Enameled Steel Sign
The Ingram-Richardson Manufacturing Co.
(See Page 713)

warning signs at highway crossing approaches, for room signs in buildings, etc.

SIGN, HIGHWAY CROSSING. A sign placed at the side of a public road a short distance from its point of intersection with a railway track at grade for the purpose of warning the public of the crossing and its possible danger.

The law in the majority of the states requires that the crossing sign be placed on the right hand side of the highway and at right angles to it where possible, and in such a position that it will not interfere with travel or be less than 10 ft. from the center line of the railway track. The type in general use consists of two crossed wooden blades inclined at angles of 45 to 50 deg. with each other and mounted on a wooden post, the background being painted white with an inscription such as: "RAILWAY CROSSING! LOOK OUT FOR THE LOCOMOTIVE" or "RAILWAY CROSSING! STOP, LOOK AND LISTEN" painted in black on both sides so that it will be clearly visible from either direction.

The general requirements of the A. R. E. A. for the construction and painting of crossing signs are as follows:

The crossing sign should be made with wooden blades 12 in. wide and 8 ft. long with mitred ends and placed diagonally at an angle of 50 deg. between blades on an 8 in by 8 in. by 16 ft. wooden post. The post should stand 4 ft. in the ground, the lower 9 ft., including the part in the ground, being painted black and the balance white. The blades should be painted white with black letters and a ½ in. black border around the blades. Border and lettering should be on both sides. Letters should be Egyptian style, 9 in. high, with the exception of connecting terms such as "for the" which should be 4 in. high. Lettering should conform to local requirements or conditions.

SIGN, RIGHT-OF-WAY. A sign placed on or near the property or right-of-way boundary line of a railway to indicate by its location and inscription the limits to which railway ownership extends.

The type generally used consists of a wood or metal post varying from 2 ft. to 6 ft. in height with an inscription painted in black on a white background, stating the exact location of the right-of-way in relation to the location of the post which is set either on the property line or as near to it as conditions will permit. Other types in use are signs mounted on posts or buildings and combinations of trepass and right-of-way signs, the inscription in the latter cases being made to cover both purposes.

SIGN, SAFETY FIRST. A sign of any distinctive character designed to keep before railway employees the primary importance of safety.

Such a sign is sometimes placed along the right-of-way on each section foreman's territory on the engineman's side of the track, 8 or 10 ft. from the nearest rail, facing the direction of approaching trains and mounted on a 14-ft. wooden post set 4 ft. in the ground. One form of wooden board for this sign is a skewed parallalogram 18 in. deep and 3 ft. long, placed on the pole with one top corner 15 in. higher than the other with the words "Safety First" painted in white letters 5 in. high on a black background. Rectangular metal signs about 3 in. by 9 in. with "Safety First" in white letters on a blue background are commonly nailed on car house and shop doors for a similar purpose.

SIGN, SECTION LIMITS. A marker placed on the line between adjoining sections to define their limits by means of symbols on the side of the post or sign facing the territory indicated. This marker is usually placed on the left hand side of the tracks and 8 ft. or more from the nearest running rail, while the symbols are near the top and 5 ft. or more above the ground, into which the post is set about 3 ft.

Some railways use a post only, with the inscriptions painted on opposite sides, while others use a small metal or wooden sign usually 6 in. deep and preferably fastened on top of the post, this arrangement permitting the use of the entire face of the sign for symbols.

SIGN, SLOW. A sign placed on a railway right-of-way for the purpose of informing trainmen of an approach to a stretch of track where the train speed must be restricted to certain prescribed limits. It is generally constructed of wood or metal and mounted on a wood, metal or concrete post set on the engineman's side about 11 ft. from the center line of the track, with the sign at right angles to the track facing the direction of approaching trains and from 6 ft. to 8 ft. above the top of rail. The inscription most commonly used consists of the word "SLOW" painted in black on a white backgroud.

SIGN, SPEED LIMIT. A marker placed at points on railway right-of-ways to indicate the maximum speed allowable over a designated portion of the line. The general construction of speed limit signs is similar to slow signs, differing only in the inscription which commonly consists of two numbers of different size painted in black on a white background. The larger number, which is generally placed above indicates the allowable speed for passenger trains, while the smaller or bottom number applies to freight trains. See Sign, Slow.

SIGN, STOP. A marker designed to instruct enginemen to stop locomotives at the sign before proceeding beyond it. It is usually a rectangular wooden board or metal sign fixed on a post at a height of 10 ft. above the top of the rail on the engineman's side of the track about 8 ft. from the nearest rail with the word "STOP" in red letters 8 to 10 in. high on a white background. This sign is principally of use at approaches to crossings of railway tracks and movable bridges which are not interlocked. They are sometimes used also to protect track temporarily obstructed for the purpose of making repairs.

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SIGN, TRESPASS. A sign displayed to warn the public against entering on or attempting to cross railway property at points other than public crossings or thoroughfares and bearing an inscription stating the ownership of the property, the probable danger to be encountered and forbidding trespass.

A trespass sign is commonly made of wood or metal with a white painted oval or rectangular face. bordered and lettered in black. It is usually mounted on a wood, metal or concrete post about 6 ft. to 8 ft. long above the ground, although in a large number of states the law specifies the size, color, height and form of the sign and the form of the inscription thereon.

The general requirements of the A. R. E. A. for the construction and painting of trespass signs are as follows:

Trespass signs should be made of cast iron, ¼ in. thick, with borders and letters raised ⅛ in. with slight draught. They should be 1 ft. 6 in. deep by 2 ft. 6 in. wide with ⅜ in. diagonal cast ribs on the back for stiffness and mounted on posts made from 2½ in. wrought iron pipe or good second hand boiler tubes filled with grout. The face of the letters and the borders should be painted black on a white background, the posts and the back of the signs being painted black. When concrete or stone foundations are not used, the pipe should be planted 3 ft. 6 in. deep in the ground and a gas pipe 1 in. in diameter and about 1 ft. 6 in. long should be run through the pipe post 1 ft. below the ground line to keep the sign from turning. The following wording is suggested though the wording should conform to the law or as far as possible under local conditions: "RAILWAY PROPERTY! TRESPASSING FORBIDDEN UNDER PENALTY OF THE LAW" "DANGER! DO NOT TRESPASS ON THE RAILWAY."

SIGN, YARD LIMIT. A sign designed to mark the terminus of a district within which trains are operated under yard rules.

This marker is commonly a rectangular metal sign or a sign of boards with beaded edging, bolted to a substantial wooden or metal post about 10 ft. high above the rail, set to face traffic and bearing on each side the inscription "YARD LIMIT" in black letters 10 in. high on a white background. It is placed a full freight train length, say 4,000 ft. from the head block as seen from the frog of the main track switch farthest from the middle of the yard, on the engineman's side and well clear of the track where it can be seen readily.

SIGNAL STAND (Slip Switch). A subsidiary target stand placed on one tie and connected with one reach rod for the purpose of indicating the line up of tracks governed through this reach rod. These target stands, two of which are necessary for a double slip switch, are separate from the switch point throwing device. See Girder Stand (Switch, Slip).

SLIDE PLATE. See Switch Plate.

SLOT SPIKING. Driving track spikes into the ties which support the rail joints so that the necks of the spikes fit into rectangular notches in the edges of the horizontal legs of the splice bars.

Rail joints are slot-spiked to arrest the tendency of the rails to creep. This method is effective in many cases where this tendency is not too marked.

In broken joint track, however, slot-spiking anchors one end of the joint tie only. This condition frequently results in slewing the joint ties with a tendency to tighten the gage. The slot inevitably weakens the joint bar, and the resistance of the joint to the wave motion results in frequent breakages of the rail at the bolt holes and of the bar at the spike slot.

On this account some joint bars have holes punched in the horizontal legs instead of slots in the edges. There is a further tendency to omit anchoring at rail joints, frogs and crossings in favor of more heavily anchoring the centers and quarters of the rails of the unbroken track which is found effective in many cases where the track foundation is not too soft, and the tendency of the rails to creep is not too marked.

SNOW CRAB. A car equipped at its rear end with high, vertically-hinged side wings adaptable to being spread to cut into deep snow on each side of the track with the vertical cutting edges of their divergent braced surfaces, in order to draw the snow in between the rails behind the car whence it may be handled with a following rotary plow, thus widening the snow cut. Drifting snow tends to refill the narrow cuts made by rotary plows during severe winter storms and the widening which may be done behind a snow crab on the return trip of the plow often saves blockades by providing ample room for traffic. See Snow Plow.

SNOW MELTER. A contrivance designed to thaw and to prevent the accumulation of snow and ice in the tracks; sometimes a blow torch designed to be held close to the snow or a steam or electrical heating device designed to be laid along the track through the switch leads, at interlockers or railroad crossings, etc.; and sometimes a chemical to be poured or strewn along the tracks.

Buckeye Thawing Outfit
The Macleod Company

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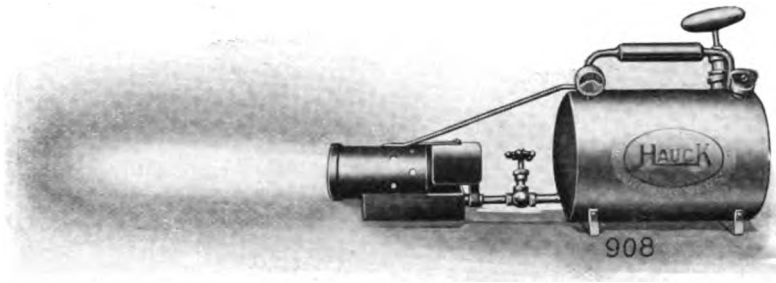
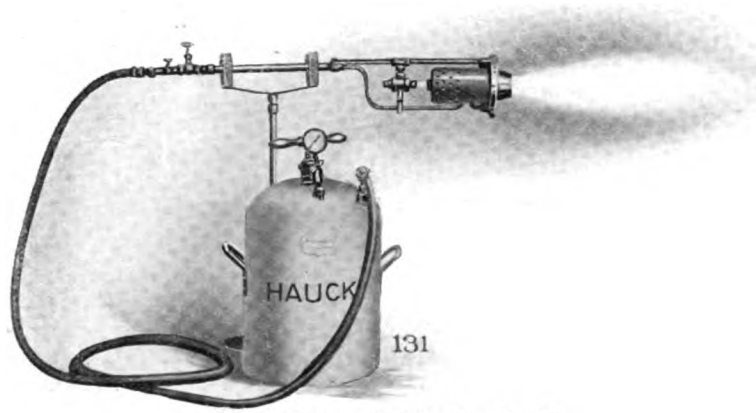
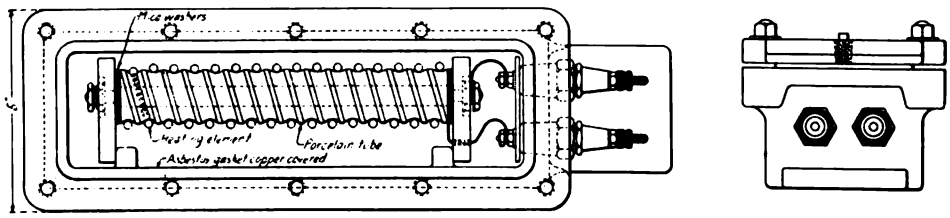
A common chemical snow and ice melter is coarse salt, which is used around switches and flangeways, railway station platforms and sidewalks, though it is forbidden to be used within the limits of interlockers owing to its corrosive action on steel.



Hauck Portable Hand Thawing Torch
The Hauck Manufacturing Co.
(See Page 703)



Hauck Pneumatic Thawing Outfit
The Hauck Manufacturing Co.
(See Page 703)



Q & C Boardman Electric Snow Melting Device
The Q & C Co.
(See Page 776)

Liquid, low pressure hydro-carbon, a residue from pintsch gas is an effective snow melter when poured in a fine burning stream from an asbestos-tipped oil can of special design. Pipes carrying live steam are sometimes employed to prevent snow and ice from accumulating around track tanks, switches, turntable circles and centers, while switch engines are sometimes equipped with special perforated steam pipes under and back of the pilot to melt the snow on each side of the rail. A common form of portable thawing device is a kerosene torch, consisting of a conical metal burner hose connected to a steel fuel tank having a capacity of from 1 to 15 gal., the oil being forced from the fuel tank by compressed air to the burner where it vaporizes and when ignited will produce a flame from 12 in. to 18 in. long, which may be regulated by a cock on the pipe connection of the burner. Air pressure is maintained by a compressed air pump attached to the top of the fuel tank which also carries a pressure gage. This device is frequently used in terminals and yards. A gas heater usually consists of a system of pipes furnished with gas jets at suitable intervals, the pipes being placed crosswise the track or between the points and stock rails of the switch, while the gas is fed into them from a feed pipe usually extending outside the ties and parallel with the track to a connection with the central supply.

The electric heater consists of a series of wire coils enclosed in a heavy water proof steel box placed directly under the rails between the ties and wire

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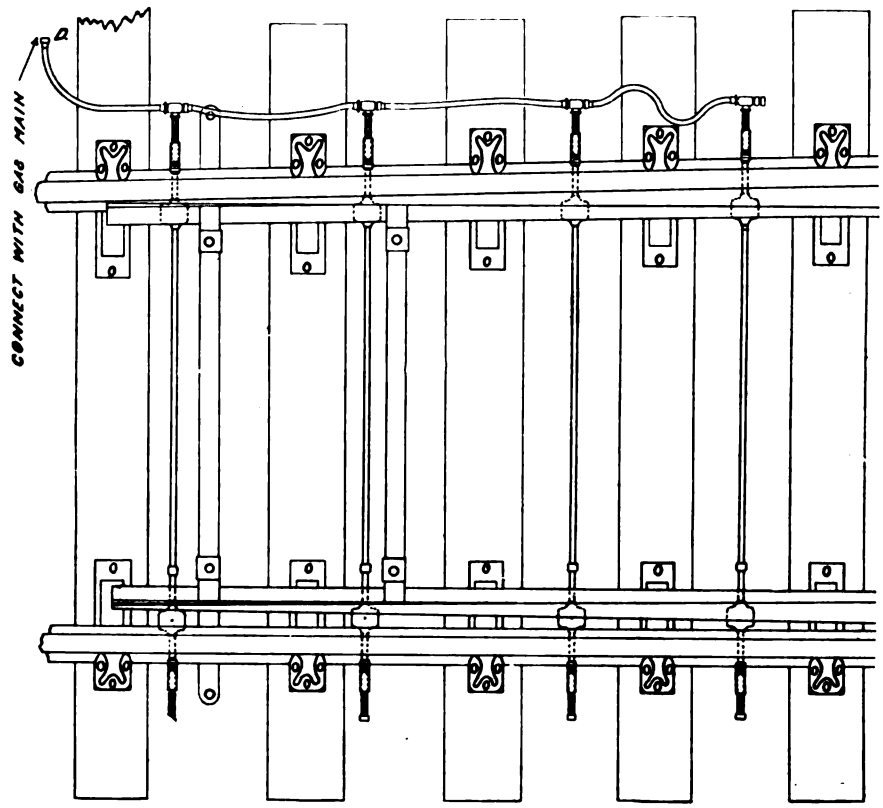
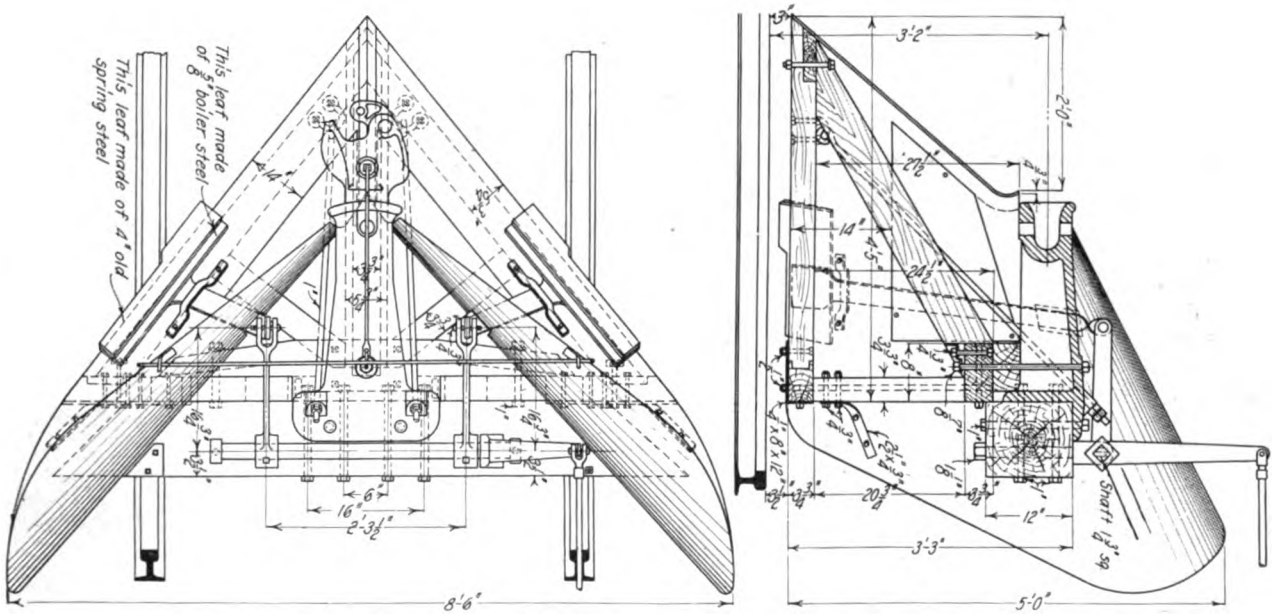


Vaughan Gas Switch Heater
The M. W. Supply Co.

connected to an electric current. This device is portable and can be readily placed in service or disconnected and removed.

SNOW PLOW. A machine for removing snow from railway tracks. It may be a complete unit such as a push plow on its own trucks or a rotary plow with its steam plant for operating the snow wheel; or an attachment for standard equipment, such as a pilot plow, a snow crab or a flanger. The various types of snow fighting equipment are designed for special conditions, flangers being intended only to free the running rails and especially the rail flanges, while push plows built to free the entire track of snow down to a level of about 3 in. above



High Wing Pilot Snow Plow
Duluth, South Shore & Atlantic Ry.

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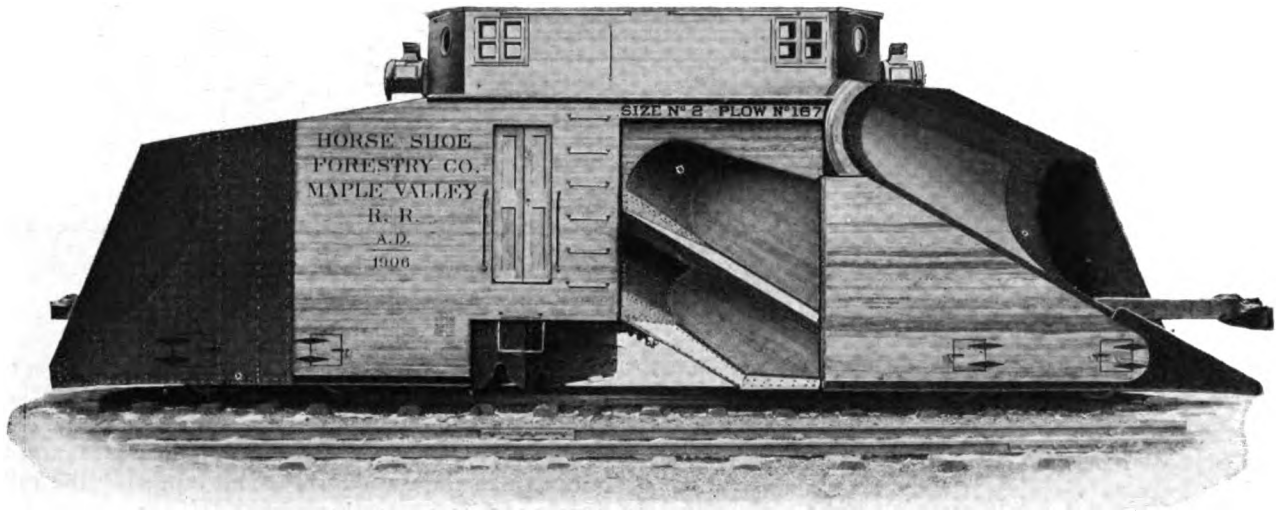
the tops of the rails are preferably fitted with vertically hinged folding side wings which may be extended to widen the cut opened with the front wedge in order to afford ample room for traffic and for the disposal of subsequent snow. Push plows and rotary plows are preferably fitted with flanger plates which may be lowered to clear a space about 10 in. to 12 in. wide on either side of each line of running rails to a depth of 2 in. below their crowns, to provide normal running surfaces for wheels.

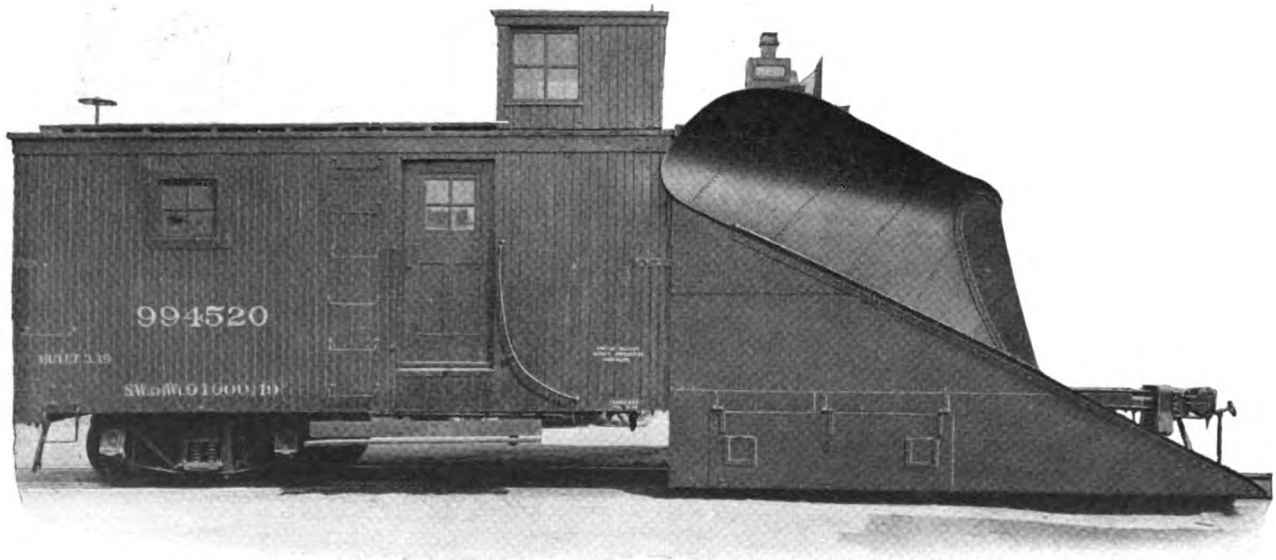
SNOW PLOW, PILOT. A locomotive snow plow attachment designed to cover or to temporarily replace the pilot of a locomotive. For heavy duty the plow is preferably built on a special pilot frame complete with oak beam and installed in place of the pilot during the winter season, this arrangement placing the plow close to the locomotive where it is more secure and effective. The sheet steel wings of the pilot plow diverge at horizontal angles of 45 deg. from the reinforced central rib which slants back about 35 deg. from the vertical with a recurve beneath the coupler casting. They also recurve diagonally as they flare out and back in order to deflect the snow up, out and away from the center of the track. Such pilot plows with wings 5 ft. high at the tips and a spread of 8 ft. to 9 ft. have a central rib which rises about 3 ft. above the nose which is set 3 in. above the top of the rail. They will handle snow as deep as 5 ft. if the drifts are not too long or hard.

Smaller pilot plows of similar form but of less wing rise and spread are designed as snow throwing covers for locomotive pilots, to the frames of which they are bolted for light snow service. Their usefulness is limited to clearing the track, while other snow equipment is employed to widen the channel.

SNOW PLOW, PUSH. A V-shaped or modified wedge-shaped railway track plow designed to free the tracks from snow to maintain traffic. The



Russell Double-End, Double Track Snow Plow, with Wing Elevator and Flanger, for Right Hand Running
The Russell Car and Snow Plow Co.



Ray Snow Plow Attached to Car
The Q & C Co.

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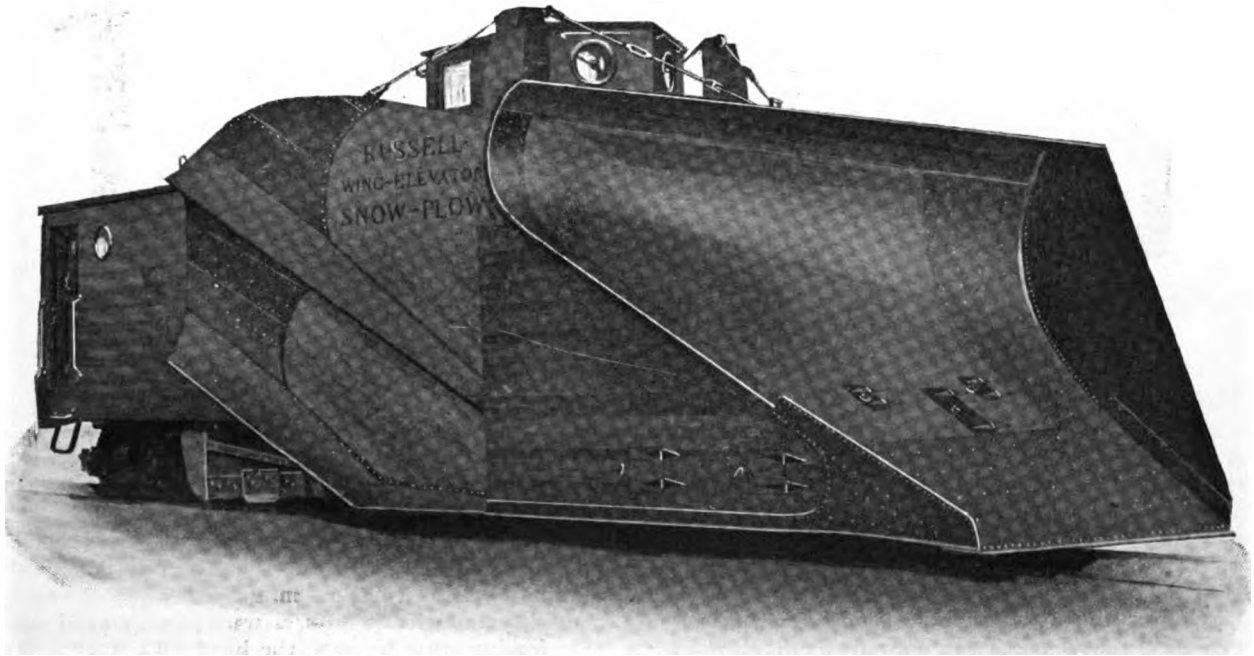
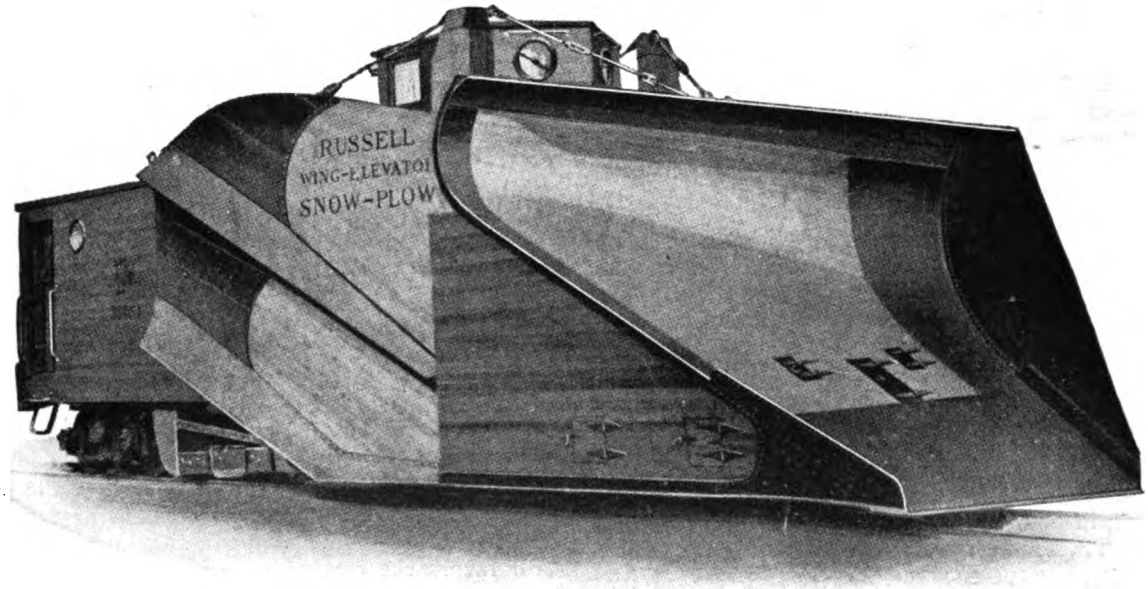
push plow may have vertical side surfaces converging to a plain upright central apex line; or the sides may flare like plow shares as they diverge from a vertical edge which is concave in profile and spreads toward the base into a horizontal front cutting edge of the width of the plow. The double track push plow is designed with the apex in line with the inside rail and one flaring wing to throw snow to the outside only.



Russell Double Track Snow Plow with Wing Elevators and Flanger
The Russell Car and Snow Plow Co.



Russell Double Track Snow Plow with Wing Elevators and Flangers
The Russell Car and Snow Plow Co.

SNOW PLOW, ROTARY. A heavy duty, steam operated railway snow handling machine housed in a special car with the front end occupied by a large hooded wheel carrying knives and scoops which, when revolved rapidly and pushed into a drift, will cut the snow and whirl it within the hood to adjustable chutes through which it is thrown up and sidewise to a distance from the track. Steam power is obtained from a locomotive type horizontal boiler located with its fire box behind the two opposite horizontal cylinders of the engine which drives the wheel by means of bevel gears on the engine shafts and main shaft. The wheel is commonly composed of 10 to 12 hollow radial steel scoops open on their front sides, while the knives are so hinged in front, one on each side of the opening as to automatically adjust themselves in snow cutting position. The excavated snow is prevented from escape except at the chutes by the surrounding fixed hood or rim

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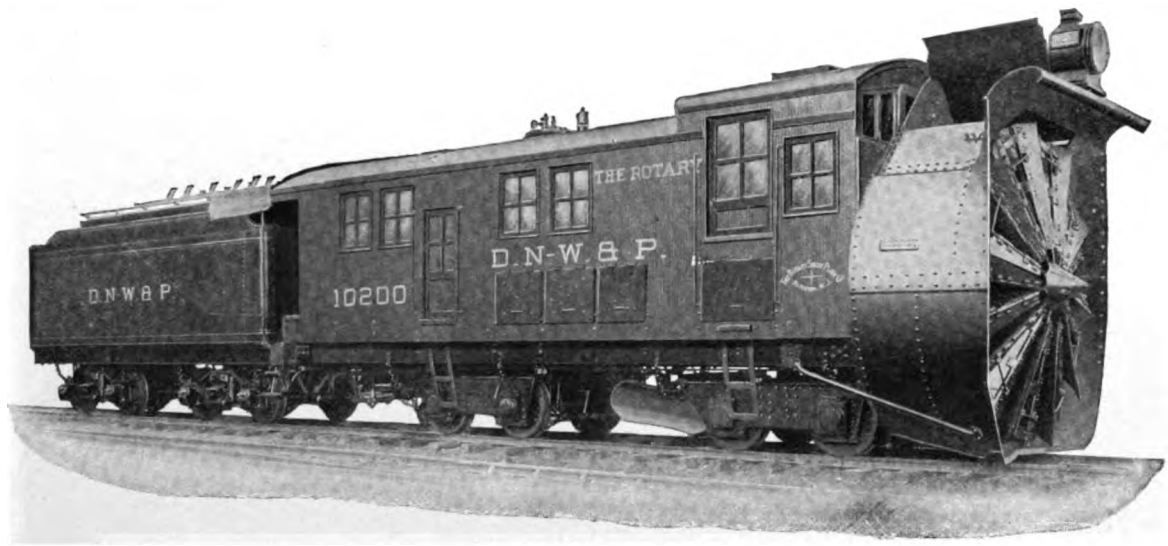


Rotary Snow Plow
The American Locomotive Company

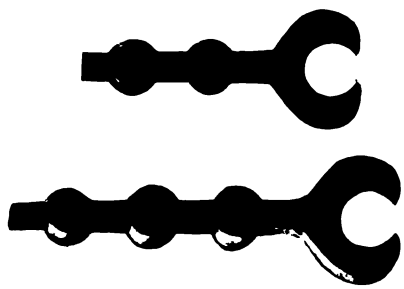
of steel plates which extends 3 in. to 4 in. in front of the scoops and has a recurved top extension to prevent the snow from obscuring the operators lookout windows. The wheel which revolves about 200 times per minute at 4 miles per hour through snow 12 ft. deep, is usually supplemented by ice cutters and flangers operated by compressed air from the cab. A rotary plow is preferably operated by a special crew of 3 men and is pushed by a special locomotive, not attached to a train.

SOCKET (Switch Lamp). A cast iron collar supporting the base of the switch lamp, and provided with a bottom recess and a set screw by means of which it fits over and grips the end of the switch stand spindle.

SOD LINE (Roadway). A line parallel with and near the edge of the roadbed which marks the limit of the growth of grass from the slope toward the ballast, within which it is not permitted to take root because it collects dirt and moisture. Sometimes the narrow space between the sod line and the toe of the ballast slope is filled with cinders to retard the growth of grass.

SPIKE, CUT. A chisel-pointed spike with a hook head designed to hold a rail, and usually a tie plate as well, in place on a tie in track under traffic. See Spike, Track.

SPIKE PULLER. A claw bar extension used for pulling cut track spikes from narrow spaces otherwise inaccessible, as the flangeways between running rails and guard rails. This one-piece tool is commonly a ½ in. by 1 in. by 9 in. straight steel bar ending in a solid symmetrical double claw of ¾ in. spread suitable for inserting beneath the head of a track spike. Between the claw and the end of the shank at intervals of about 2 in., rivets are driven through the bar to serve as holders for the toes of the claw bar. When the puller claw is adjusted beneath the spike head and the shank is inserted edgewise with a rivet bearing above and between the jaws of a claw bar which rests on the top of the rail, the spike is readily drawn by applying leverage to the bar.



Two Knob and Three Knob Spike Pullers

SPIKE, SCREW. A cylindrical, blunt ended, wood-threaded, disc-headed, steel screw with a tapering, square-section cap designed to be turned with a special wrench into pre-bored holes in wooden cross ties to secure the rail flange and tie plate thereto, and to hold these track members in their correct relative positions. See Spike, Track.

SPIKE, TRACK. A spike designed to hold the ordinary tee rail to the wooden ties in railway tracks under traffic.

The development of means of fastening the rails to the ties constitutes a fundamental problem in track construction which was solved so well at the inception of railway building in America, as demanded by the exigencies of the moment, that present practice still favors the early form of spike practically unchanged except as to increases in size and strength. Screw spikes of various patterns and spiral spikes designed to be driven are later types, developed to provide increased holding power and to decrease the crushing of the wood fibre of the tie.

Cut Spike

Of these types, the cut spike which was for many years the only style manufactured, is still in general use. Although some slight alterations in form have been made, the head remains a flat hook head, the section of the shank remains square and the point is still a chisel point. The design recommended as standard by the A. R. E. A. is of ⅝ in. square section and 5½ in. to 6 in. long from the point to the under side of the head, which declines slightly forward,

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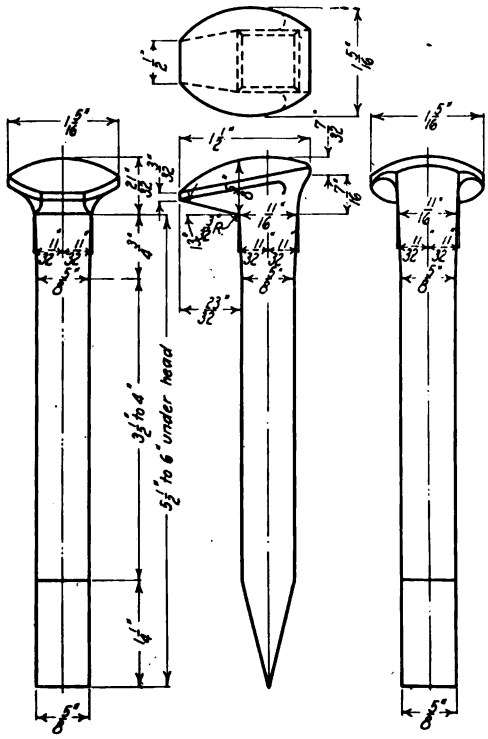
while the face beneath the hook terminates in the edge of the chisel point which is 1¼ in. long. This spike is made of steel tough enough to bend double without breaking. It is designed to be driven into a cross tie with the chisel edge across the grain of the wood and parallel to the rail while the hook of the head is toward and laps over the flange of the rail to hold it to the tie.

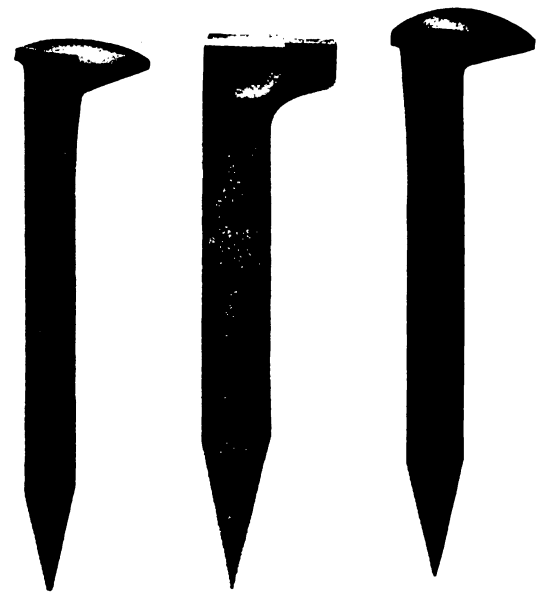


A. R. E. A. Standard Cut Track Spike

The forward bend in the head facilitates straight driving and ease in pulling, while the neck reinforcement beneath the head adds strength to the portion which must withstand the most severe stresses and wear, especially the side thrusts of wheel flanges on the rail, the flange of which bears directly against the neck of the spike. The length of the spike is based on the thickness of the tie with allowance for adzing and for the thickness of the rail flange and tie plate. In general, 6 in. spikes are considered long enough for 7 in. ties, although longer spikes are sometimes used where thick tie plates and rail flanges require them, or for shimming. The points of spikes are generally cut to a chisel edge, but are sometimes rolled to a rounded chisel edge like an axe blade, or narrowed, or side cut to a pyramid shape. Points of spikes are turned 45 deg. to 90 deg. from the standard design when manufactured to hold rail on longitudinal timber to avoid splitting the wood.

Characteristics which have led to the standardization of cut track spikes are that they are readily manufactured and transported in great numbers and in convenient packages. Their cost per mile of track is comparatively low, the spikes are readily handled, applied, withdrawn and re-applied. They wear well, they are reclaimed at small cost and have a fair value as scrap. Disadvantages are that hand driving demands some skill and is heavy labor. Inaccurate driving tends to injure the rails, bend the spike and result in accidents to employees. The driving of the spike tends to crack and diagonally depress the surrounding fibre of the tie on lines readily followed by moisture and consequent decay. The spike holds the rail down to the tie only by means of friction against this depressed fibre. The vertical reverse stresses on rail under traffic combined with the side thrusts of wheels, which are transmitted to the rail flange, tend to loosen gradually and lift the spike and destroy its holding power, while the friction of the rail flange against the neck acts to wear away the metal and throat-cut the spike, which will not hold the rail to gage after being so worn

Spikes are driven by hand with a two-faced spike maul and are staggered with respect to the edges of the tie with a view to preventing the tie from slewing in the track. Four spikes are ordinarily driven in each tie, the base of each rail being held between two spikes which are driven about two inches from oppsite edges of the face of the tie. The two spikes holding adjacent edges of opposite rail bases inside the track are driven in the near side of the face of the tie, while the outside spikes are driven in the far side, as seen when facing in the direction in which the rail is being laid. On curves, at turnouts and wherever the side thrusts of traffic are especially severe, the outside edge of the outer rail is frequently double spiked to hold the rail to gage. Sometimes the inside edge is also double spiked to keep the rail from tilting. In some cases both rails are double spiked outside or inside or on both sides to resist the various stresses of traffic. Tie plates are frequently punched with four holes on this account.



1. Cut Spike with Flare in Front
2. Dog Eared Cut Spike
3. Cut Spike with Flare on Back

When a spike is to be driven the tie should be held up against the rail base to obtain a solid bearing. This is usually done by a laborer with a wooden block and a track bar used as a lever. Spikes are usually driven first at the joints, then at the half and quarter points of a rail. This preliminary spiking is called quarter-spiking. Full spiking is usually done immediately after the quarter-spiking.

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In laying track the rails are spiked to gage after being set up on the ties and jointed together, before any ballast is applied. If necessary the ties are bedded with earth under the rail bearings just enough to keep the track in reasonable surface during construction.

Cut track spikes are shipped in kegs or bags weighing 200 lb. each, containing about 300-⅝ in. by 6 in. spikes.

Although they are satisfactory in nearly every other respect, cut spikes are so destructive of wood fibre that spike killing is the cause of many ties breaking under the rail bearing, and a large percentage of tie failures from mechanical wear are due primarily or directly to cut spike holes and the crushing of the surrounding fibre is due to spiking. On account of this destructive tendency of the cut spike, the search for a substitute that would injure the tie less and hold better resulted in the invention of the screw spike.

More recently a modified screw spike has been developed designed to be driven in the same way as a cut spike and at the same time to diminish the cutting of the wood fibre.

A. R. E. A. Specifications for Cut Spikes

I. Material

1. The steel may be made by the Bessemer or open-hearth process.

II. Physical Requirements

2. **Tension Test.** The full-size finished spikes, or the full-size bars from which the spikes are made, shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in..55,000
Yield point, lb. per sq. in.....0.5 tensile strength
Elongation in 2 in., per cent....25.

3. **Bend Tests.** (a) The body of the full-size finished spike shall bend cold through 180 deg. flat on itself, without cracking on the outside of the bent portion.

(b) The head of the full-size finished spike shall bend backward to the line of the face of the spike, without cracking on the outside of the bent portion.

4. **Number of Tests.** (a) One tension and one bend test of each kind shall be made from each lot of 10 tons or fraction thereof.

(b) If any test specimen develops flaws, it may be discarded and another specimen substituted.

5. **Retests.** If any tension test specimen breaks more than ¾ in. from the center of the gage length, a retest shall be allowed.

III. Design

6. **Workmanship.** The spikes shall conform to the dimensions specified by the purchaser. A variation of 1/64 in. under the specified dimension of the body of the spike, measured from the face to the back, and a variation of $\frac{3}{32}$ in. over the specified dimensions of the body of the spike, measured across the face, will be permitted. A variation of $\frac{3}{32}$ in. over and $\frac{3}{32}$ in. under the specified dimensions of the head of the spike will be permitted. A variation of ⅛ in. from the specified length of the spike, measured from the under side of the head to the point, will be permitted. A variation of 1 deg. in the specified angle of the under side of the head of the spike will be permitted.

IV. Manufacture

7. **Finish.** The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

V. Inspection

8. **Inspection.** The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's work which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

9. **Rejection.** Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

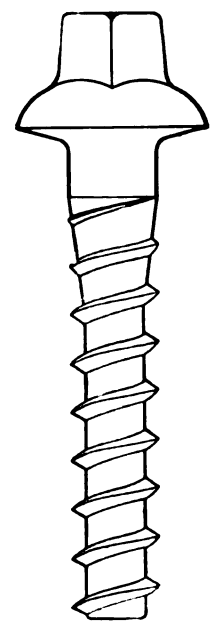
VI. Shipment

10. **Packing.** When spikes are shipped they shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size of spike and name of manufacturer.

Screw Spike

The screw spike is cylindrical with a screw thread and a washer-like circular head surmounted by a square-section tapering cap, on which a special form of track wrench fits. The length of the spike is about 6½ in. to 7 in. over all and 5½ in. to 6 in. under the head. The diameter of the neck is 25/32 in. to ⅞ in. and the threads of the screw portion are cut inside this diameter to a form and pitch readily applicable to wooden ties. The diameter inside the threads is ½ in. to ⅝ in. and the point is blunt. Screw spikes are ordinarily shipped in 150-lb. kegs, holding 125 to 190 spikes each. They have been used in tests on a number of roads and in quantities on a few railways since 1910 and are reported in some cases to afford decided increases in lateral and vertical resistance over the cut spike when either tight or loose. They are usually applied in pre-bored tie holes which should be deeper than the length of the spike and which should be bored in the ties before treatment. In applying the spikes they are driven with a hammer only far enough to start the thread into the wood and from that point they are screwed until properly seated.

Screw spikes are preferably used in connection with tie plates having a shoulder to support the head of each spike. It is said to be unusual to find hard wood ties with weakened fibre about the screw threads, but in case the fibre is destroyed, a screw lining or dowel may be placed in the hole. Screw spikes do not require as frequent periodical tightening as do cut spikes, but should be tightened once after being inserted, after the tie plate has become properly bedded.



Screw Track Spike

Sessler Grip Track Spike
The American Spike Co.

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Some disadvantages of the screw spikes are that their first cost is greater than cut spike, they require pre-bored holes, special tie plates, special track tools, more time and labor for installation and removal, and are not so adaptable to reclamation. Their general use depends largely on the comparative cost of maintenance of track equipped with cut spikes.

A. R. E. A. Specifications for Screw Spikes

I. Material

1. **Process.** The steel may be made by the Bessemer or open-hearth process.
2. **Finishing.** The heads of the spikes shall be formed and the threads rolled at a temperature not less than 750 deg. C.

II. Physical Requirements

3. **Tension Tests.** The full-sized finished spikes shall conform to the following minimum requirements as to tensile properties:
Tensile strength, lb. per sq. in..60,000
Yield point, lb. per sq. in.....0.5 tensile strength
Elongation in 2 in., per cent...20.
4. **Bend Tests.** The full-sized finished spikes shall bend cold through 90 deg. around a pin the diameter of which is equal to three times the diameter of the spike, without cracking on the outside of the bent portion.
5. **Number of Tests.** (a) One tension and one bend test shall be made from each lot of 100 kegs or fraction thereof.
(b) If any spike tested develops flaws, it may be discarded and another spike substituted.
6. **Retests.** (a) If the percentage of elongation of any tension test spike is less than that specified in Section 3, a retest shall be allowed.
(b) If any tension test spike breaks more than ¾ in. from the center of the gage length, a retest shall be allowed.

III. Design

7. **Workmanship.** The spikes shall conform to the dimensions specified by the purchaser. The head shall be concentric with, and firmly joined to the body of the spike. The threads shall be sharp and true to gage and of the pattern specified by the purchaser. A variation of 1/32 in. over the specified diameter of the unthreaded portion of the body of the spike will be permitted. A variation of 1/32 in. over the specified diameter of the threaded portion of the spike will be permitted. A variation of 1/16 in. under and 1/8 in. over in the reach of the head of the spike will be permitted. A variation of 1/8 in. from the specified length of the spike will be permitted.

IV. Manufacturer

8. **Finish.** The finished spikes shall be free from injurious defects and shall have a workmanlike finish.
9. **Marking.** A letter or brand indicating the manufacturer shall be pressed on the head of the spike while it is being formed.

V. Inspection

10. **Inspection.** The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.
11. **Rejection.** Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

V. Shipment

12. **Packing.** When spikes are shipped they shall be properly oiled to prevent rusting and shall be packed in good, serviceable packages. All packages shall be plainly marked as to material, size of spike and name of manufacturer, unless otherwise specified.

SPIRAL. A form of curve applicable to joining straight track with circulars curves. See Easement Curve.

SPLICE. (Rail). See Rail Joint.

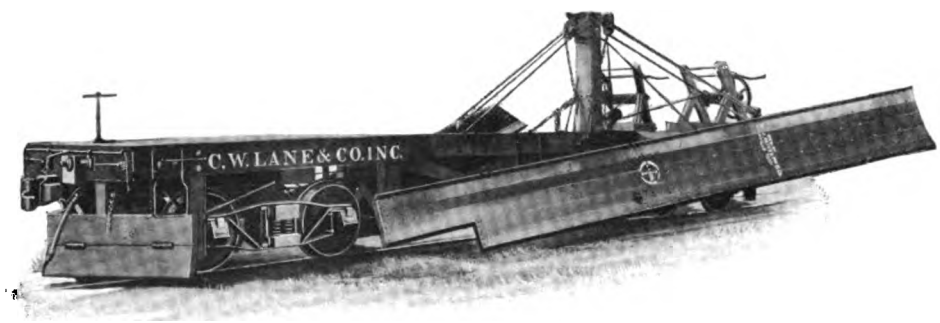
SPLICE BAR. See Joint Bar.

SPLICE STRAIGHTENER. A portable jack or press designed to straighten bent joint bars in low rail joints without removing them from track. This device, which is similar to a rail straightener, commonly consists of a steel frame, with a screw and a cross bar. It is formed so that when the frame rests on the head of the rail over the joint, a pair of depending jaws extend below the base of the rail and admit through opposite slots, a cross-bar which clamps the straightener to the joint when the capstan-headed screw, working in the threaded lever end of the frame is turned to raise the clamp and straighten the joint. This straightener can also be used with bearing blocks to serve as a rail bender.

SPLIT HEAD (Rail). A rail head from which a portion has been sheared, or which shows a crack likely to result in such a partition. Head splits usually occur at or near the center line or web of the rail.

SPLIT WEB (Rail). A longitudinal parting of the steel along the axis of the web, usually beginning at the end of the rail and extending through the bolt holes.

SPREADER. A car fitted with movable side wings, usually supplemented by or meeting to form a push plow at the forward end, operating diagonally to the center line of the track for the purpose of leveling distributed ballast or other material down to the top of the rail or lower and spreading it over the surface of the road bed. It is also used for



Oliver Spreader Car
The Wm. J. Oliver Manufacturing Co.

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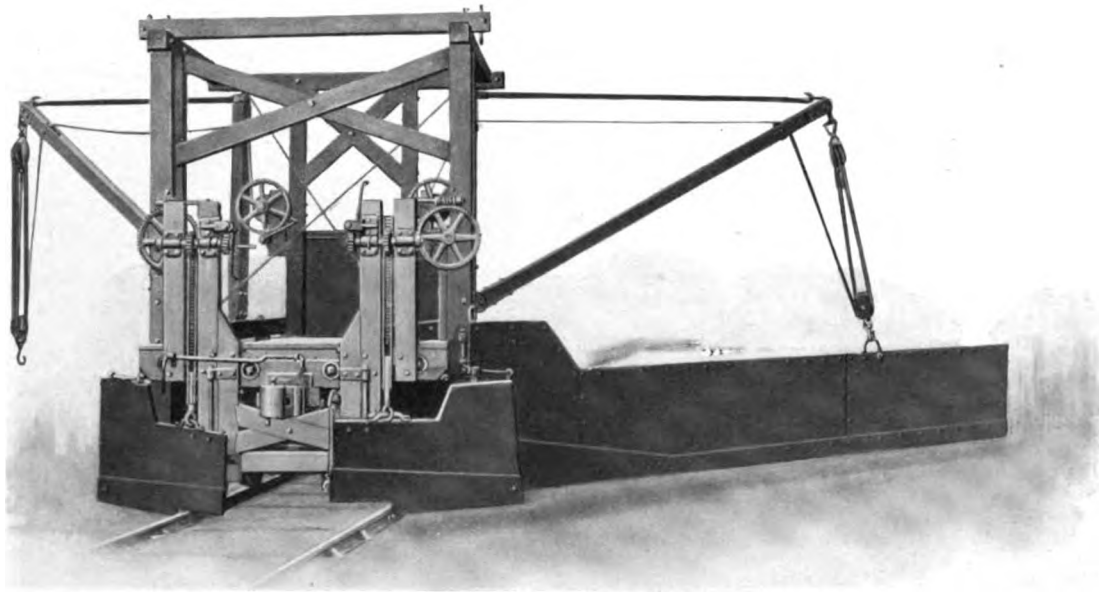
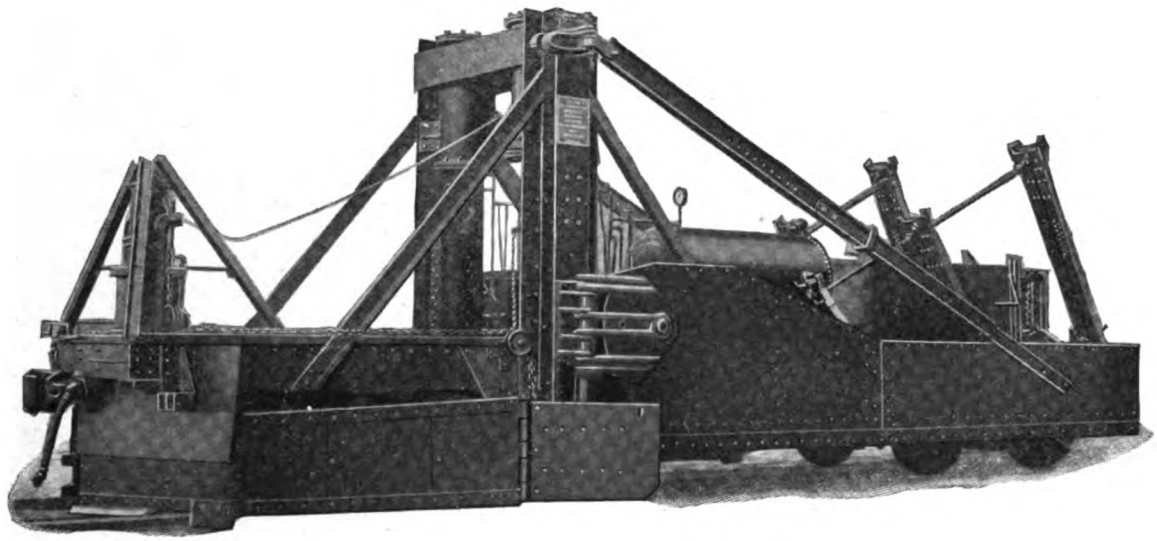
widening embankments and excavations, and is sometimes equipped with extension wings for widening road beds, deepening side ditches in cuts, clearing snow from track, etc.

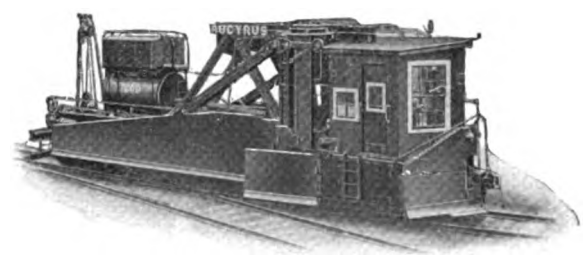
The wings of a spreader are usually of steel, strongly braced and adjusted to rise or fall, to flare widely to the side when operating and to fold against the side of the car when not in use. They are commonly operated by compressed air derived through the train line from the locomotive, the width of spread being varied by extending or withdrawing the wing braces which are attached to an upright diagonally-braced steel frame spanning the car crosswise near the forward end. This frame consists essentially of two plumb posts to which the wings and main braces are hinged and a top connecting the cross beam or beams with the necessary chains, pulleys and gears and other operating attachments. Some spreaders are supplied with flanger plows to clear material from the center of the track to a level of about 2 in. below the top of the rail when lowered by compressed air to working position.



Western Spreader Car
The Western Wheeled Scraper Co.
(See Page 834)



Jordan Spreader
The O. F. Jordan Co.
(See Page 724)



Bucyrus Spreader Plow
The Bucyrus Co.

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SPRING (Frog). A coil spring fitting over the spring bolt of a spring rail frog, the purpose of which is to press the movable spring rail against the point of the frog. A spring may be either single or double coil. When double coil, the outside spring is termed the large coil and the small coil is known as the inside coil.

SPRING FOLLOWER. A metal cylinder designed to receive the pressure of a coil spring. In spring frogs the coil spring is held in place by follower blocks, one on each end of the spring bolt.

STATION GROUND. That part of the property of a railway company which is set apart and used for depots, platforms, side tracks, driveways, lawns, warehouses and other station purposes.

A station ground is usually unfenced and occupies extra land on one or both sides of the center line of the right-of-way. Cattle guards between the ends of right-of-way fences ordinarily define station ground limits.

STAY ROD (Clamped Frog). One of two steel rods ¾ in. in diameter and about 3 ft. 6 in. long, used to secure and adjust the clamps of a clamped turnout frog.

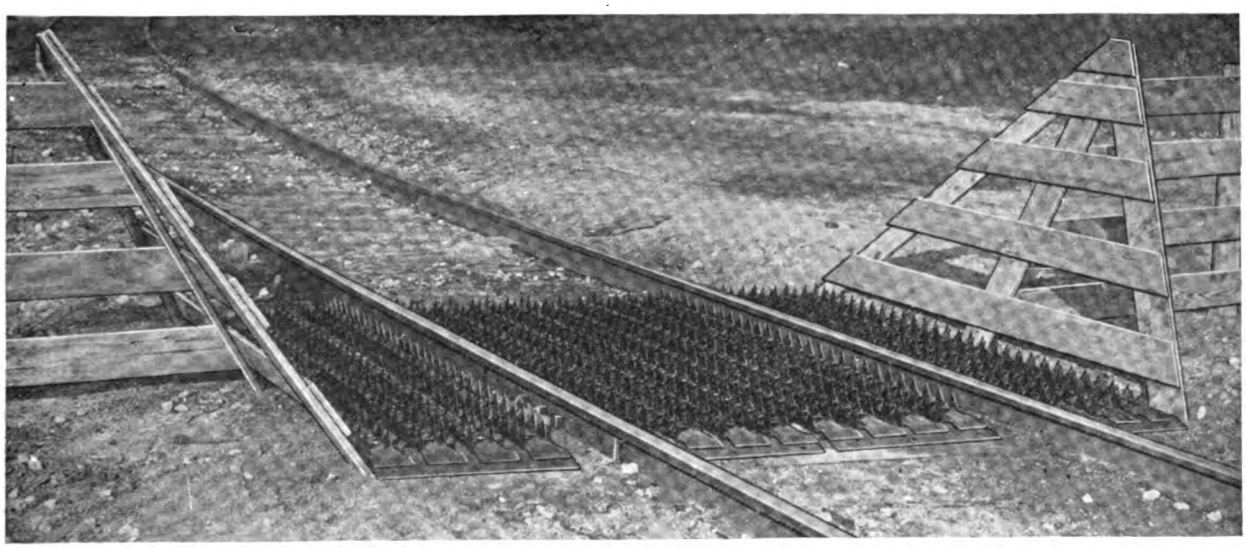
One end of the stay rod is bent, flattened and punched to receive a ¾ in. bolt which fastens it to the web near the heel of the wing rail, whence it extends forward through both clamps which it holds in adjustment against the converging wing rails by means of two 5/16-in. cotters which bear against the forward surfaces of the clamps. Adjustment is effected by means of 6 holes punched in the rod at short intervals in any one of which the cotter may be fastened to hold the clamp behind it.

STOCK GUARD. A device placed in the track and across the roadway between the ends of wing fences to complete the right-of-way enclosure with a view to preventing live stock from trespassing on railway tracks.

A prepared pit under the track, spanned by an open-top culvert between the abutments of which the track rails are carried on longitudinal running timbers without cross ties, constitutes the pit guard, which antedates the surface type but which is now generally considered obsolete because of the danger and maintenance costs involved. The type of stock guards in general use are surface stock guards made either of wood or metal, usually in three or more sections consisting of parallel rows of edged or toothed slats or ridged plates fastened to the cross ties, between which the top ballast is preferably removed, the open spaces below the section combining to offer such insecure footing as to keep live stock from crossing. At the end of the wing fence at either side of the stock guard an inclined apron fence panel is set parallel to the track. leaning away from the rails at an angle of about 45 deg. to provide clearance for rolling stock.

Wooden surface stock guards commonly consist of wedge-shaped oak or pine slats from 3½ in. to 4 in. deep and from 5 ft. to 8 ft. long, laid parallel with the rails and bolted together in sections, two sections fitting between the rails and one or more sections on the outside of each rail. The slats are usually assembled in rigid parallel rows, held together between wood or iron spools or spacing blocks by means of three or four steel rods about ⅜ in. in diameter, the ends of the slats being fastened to beveled cross pieces, and the sections being held down on the ties by track spikes driven at each end. Additional sections supported on ties or planks are commonly placed between tracks at double or multiple track crossings.

Metal surface stock guards are also made in sections, usually of perforated metal plates spiked flat on the ties but having triangular pieces bent upright to form sharp spikes; or of a series of parallel slats made of steel angles; or of parallel strips of sheet steel set on edge, the upper edges being saw-toothed. These types are designed with projecting surfaces which are set close together so that the feet of horses or cattle will not be caught between them. The sharp points of the projecting surfaces prevent cattle or horses from obtaining any suitable footing, thereby repelling animals which seek to cross over them.



National Steel Surface Stock Guard
The National Surface Guard Co.

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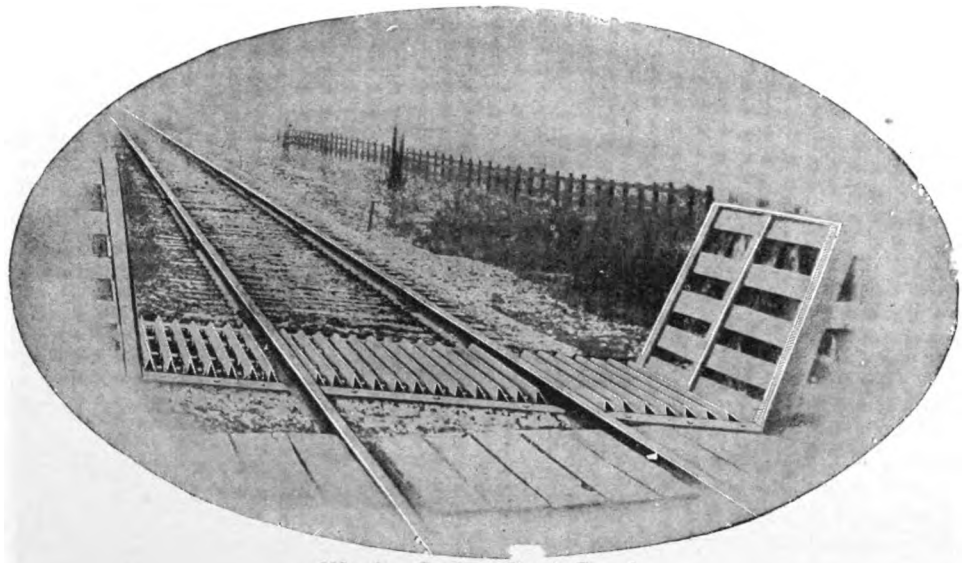
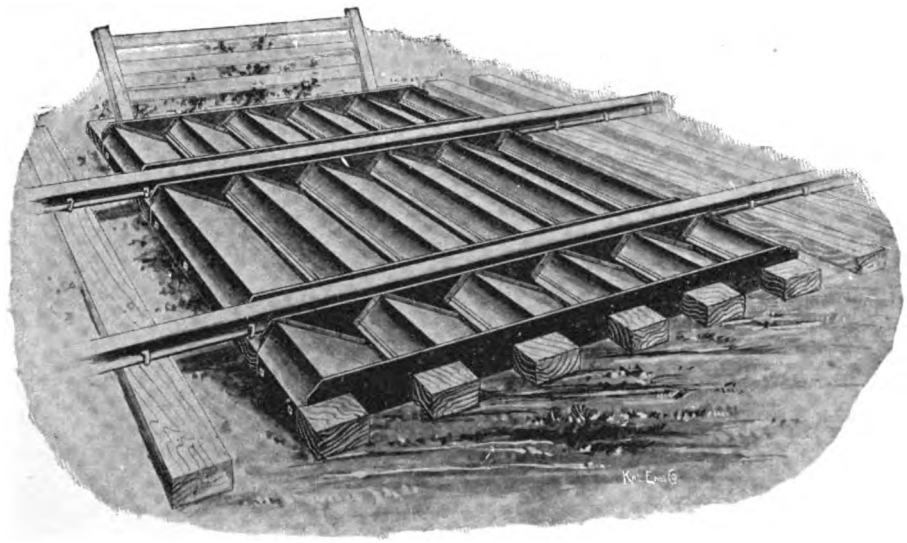


Wooden Surface Stock Guard
The Kalamazoo Railway Supply Co.
(See Page 729)



Steel Surface Stock Guard
The Kalamazoo Railway Supply Co.
(See Page 729)

Stock guards are generally required at railway grade crossings over all fenced public highways.

The general requirements of the A. R. E. A. for surface stock guards are as follows:

(1) A stock-guard should be so constructed as to avoid projecting surfaces liable to be caught by loose or dragging portions of equipment.

(2) It should be effective against all live-stock, have no parts which will catch or hold animals or unnecessarily endanger employes who pass over it in the discharge of their duties.

(3) It should be reasonable in first cost, durable and easily applied and removed, so as to permit repairs to the track at minimum expense.

(4) It should not rattle during the passage of trains.

STOP, SWITCH RAIL. A U-shaped steel strap designed to be riveted or bolted to the web of a split switch rail to hold it in proper alinement by bearing against the stock rail.

One stop near the heel of the switch is considered sufficient for 11 ft. and 16 ft. 6 in. switch rails while three stops are used for 30 ft. switch rails.

STRAIGHT PORTION (Guard Rail). The middle portion of the guard rail which lies parallel to the running rail and between the points of flare of the guard rail ends.

STRETCHER, FENCE. A tool designed to be used in the erection and repair of wire fencing, for the purpose of pulling and holding the wire in tension while it is being fastened between the straining posts.

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This tool consists essentially of a ratchet wheel or other tension device with suitable end lines, usually chains. In stretching woven wire fence the chains are attached to parallel posts in order that an equal pull may be obtained on the entire height of the fencing. See Fence.

SUBSIDENCE. The act of settling or sinking to a lower level, as of the ground under the pressure of an embankment. That portion of a railway embankment which lies hidden below the original surface of the ground is also known as subsidence. The extent of this sunken yardage varies with the character of the foundation, from nothing when the bank is built on solid rock to 100 per cent or more in some swamps and sink holes. A study of subsidence of various sub-soils led the A. R. E. A. to the tentative establishment of a ratio of settlement to the height of fill, the average appearing to be 1 per cent of subsidence per foot of fill height, or 10 per cent subsidence in a fill originally 10 ft. high. In general the settlement under railway embankments usually exceeds expectations and may be determined by cross sections obtained from soundings. Subsidence and shrinkage are distinct types of settlement separable only by estimate. See Roadway.

SWITCH. A device consisting essentially of two movable rails with the necessary connecting and operating parts, designed to divert rolling stock from one track to another gradually and without shock.

One pair of switch rails with the necessary rods, rail braces and fastenings, and the slide plates, if any, make up what is commonly known as a switch complete. Switch rails are made of standard rails of the same section as the running rails of the parent track in which the switch is to be laid, of lengths which will be suitable for the selected switch angle and which will cut most economically from standard 33 ft. rails. It is considered good practice to use switch rails 11 ft. long for switch angles greater than 1 deg. 45 min., as in turnouts sharper than No. 8; switch rails 16 ft. 6 in. long for switch angles of 1 deg. 30 min. to 2 deg., as in No. 8 turnouts; switch rails 22 ft. long for switch angles of 1 deg. to 1 deg. 30 min., as in No. 11 turnouts and switch rails 33 ft. long for switch angles of less than 1 deg., as in No. 16 turnouts. The fixed ends of the switch rails constitute the heel of the switch and the opposite ends the toe of the switch. The heel ends of the switch rails are connected to the abutting running rails by means of standard rail joints. The switch rails are not spiked to the ties but are free to move sidewise around the heel ends as pivots. This movement which is known as the throw, is usually limited to 4¾ in.

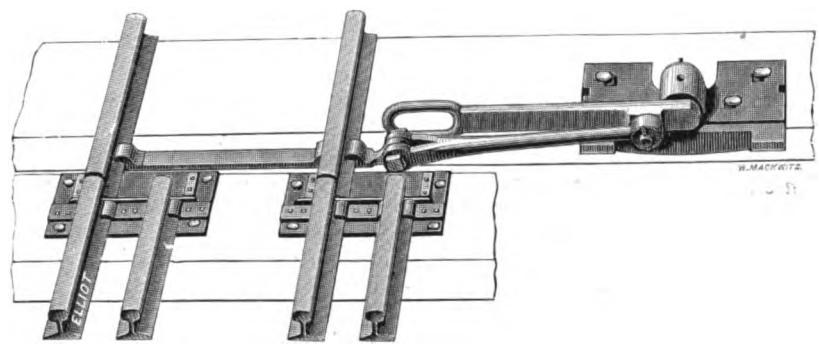
The rails of a switch are held in their correct relative positions in track by means of from two to five flat steel tie bars called switch rods, which extend across the track from rail to rail between the ties. The rods nearest the toe of the switch, known as the No. 1 switch rod, is usually located 12 in. back from the toe. The No. 2 and other rods, if any, are placed further back, the number depending on the lengths of the switch rails and on the distance between the ties. With switch ties spaced 19 in. center to center a 22 ft. switch is usually provided with four switch rods, spaced 3 ft. 4 in. centers, while a 16 ft. 6 in. switch usually has only two rods, which may be variously spaced.

A switch traversed by wheels before they reach the frog is termed a facing point switch. One traversed by wheels after they pass the frog is termed a trailing point switch.

The principal types of switches are the stub switch, the split switch and the slip switch, developed in the order named.

Stub Switch

A stub switch consists of a pair of movable rails joined to the parent track rails at the end farthest from the frog, while the opposite ends are free to move into line with the rails of either the turnout or parent track, which rails are fixed in position and are sawed squarely off at the toe. The free ends of the switch rails and the adjacent ends of the turnout and parent track rails are supported on a head shoe or chair fastened on the head block, which block usually extends far enough to also support the switch stand, or other operating mechanism.



Stub Switch

The head shoe may be either a casting or a steel plate with lugs. It is designed to afford a rigid support for and to maintain a fixed clearance between the ends of the movable and fixed rails. On one half of the shoe the squared end of the switch rail slides sidewise between two stops which limit the extend of the throw. On the other half, the squared ends of the parent and turnout rails are held rigidly in place by lugs to line with the switch rail at either extremity of its throw. Some head shoes have a ridge on the switch rail half which limits the movable rail to one of the two desired positions in line with an abutting fixed rail end, a foot lever being provided to lift the switch rail above this ridge while being thrown. The head shoe is usually spiked, but is sometimes bolted, to the head block.

For many years the stub switch was the only device in general use to lead wheels onto a turnout. Its parts are few and simple and it was readily adaptable to the rough and ready methods in use in the early stage of railway development. It requires

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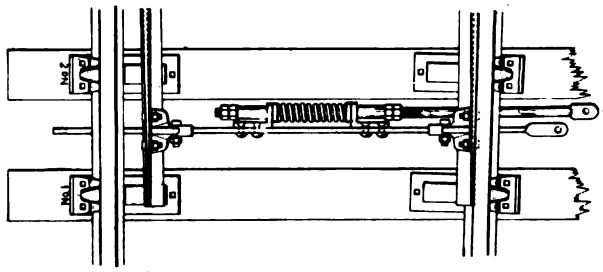
no specially tooled switch rails nor fine adjustments. It does however, require the permanent loosening of two opposite main track rails and in broken joint track it requires that at least one main track rail be cut. The principal difficulty arose from the creeping of the rails which frequently resulted in crowding the ends into contact so that the switch could not be thrown. Also in case a stub switch is slightly out of adjustment or a rail is not held rigidly in



Split Switch with Spring Head Rod
The Morden Frog and Crossing Works

position, the gage sides of the abutting rail heads may not come into exact line and the lip or offset thus created is dangerous, especially to sharp wheel flanges which may climb the rail end at this slight obstruction and be derailed. These disadvantages led to the development of the split switch.

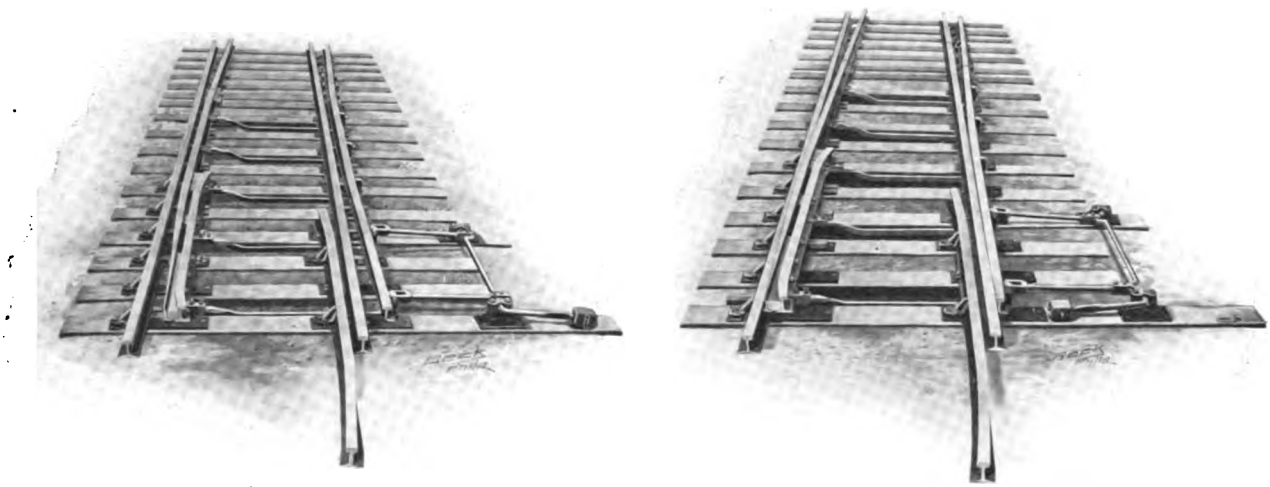
Split Switch

A split switch consists essentially of a pair of tooled rails made of carbon steel with or without manganese steel tips or of rolled manganese steel, which are of full section at the heel but are planed and bent to thin tapering vertical edges at the point ends, which are so connected by means of switch rods with clips that they may be placed between the two continuous outside lines of rails of a turnout, resting on suitable metal base plates, with the points free to move sidewise from one stock rail to the other, the heel ends being joined to the fixed rails behind them. The switch point rails are less than the standard gage distance apart so that when one point is against the stock rail the opposite point stands far enough inside the running rail to clear the wheel flanges. In this manner the diversion of one wheel flange guides the pair into the turnout. The switch is thrown either by means of a connecting rod and switch stand with a lever or by some form of an interlocking device.

It is not practicable to manufacture switch point rails to the theoretical angle, so it is necessary to provide a housing for the switch point by kinking the head of the stock rail or by milling it ¼ in. or more to cover the switch point. Although the former is the common method, the latter is more effective. The points of switch rails are planed to ¼ in. thickness and thereafter ground to ⅛ in. thickness, starting 2 ft. back from the point, which is then ground sharp to a quarter round at the top edge within a radius of ½ in.

The No. 1 rod is usually located 12 in. back of the points, although it may be placed as far as 17 in. back when required to conform to interlocking connections. The No. 1 rod is preferably long enough to extend beneath the bases of both running rails to act as a hold-down and to connect with the throwing device. All of the switch rods are placed flatwise and they are attached to the webs of the switch rails by means of raised clips. They are usually made of ¾ in. by 2½ in. flat mild steel, although they were formerly made of round iron with clamp-shaped ends which gripped the rail flanges, this style now being common only in stub switches. The switch rods are designed to hold the switch rails rigidly in position, adjustments of various kinds sometimes being provided on No. 1 and No. 2 rods to overcome the effects of rail wear and maintain the correct distances between the gage sides of the switch rails. Some switch rods are made in two parts and supplied with a screw adjusting device. Others are made in two parts and are provided with a strong spring to allow wheel flanges to trail through the switch if set the wrong way, without injury to the points.

At or near each end of a switch rod is a device by which the rod is joined to the switch rail. Usually this fastening is a clip which is bolted to the rod and to the web of the switch rail. One style of clip has a U-shaped end which fits over and under the rod, while a threaded bolt secured with a cotter passes vertically through the rod and both



Unbroken Main Line Switch in Open and Closed Positions
Wm. Wharton, Jr., & Co., Inc.

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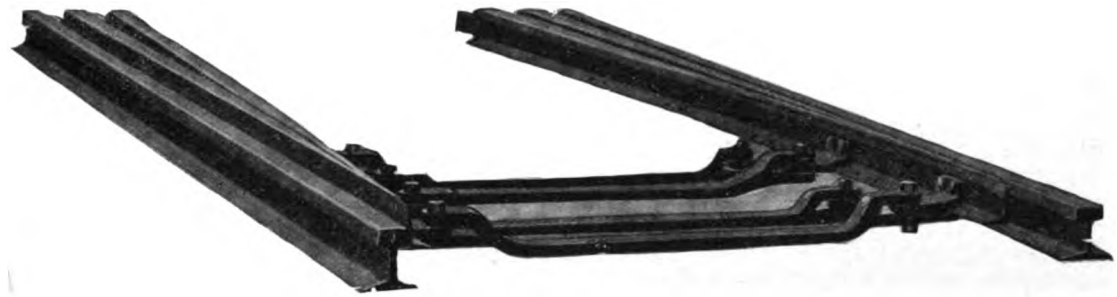
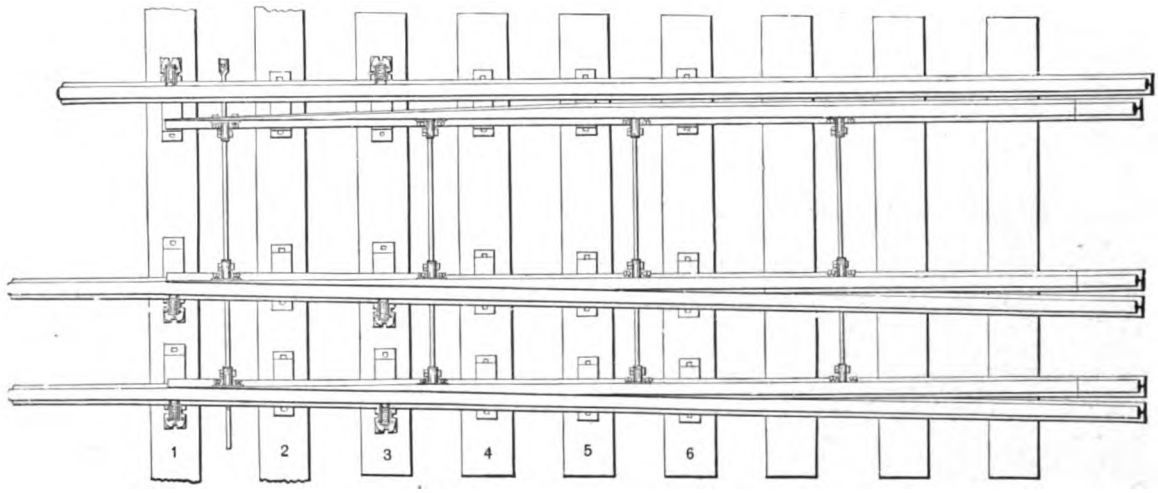
jaws of the clip, fastening them together by means of a top nut and cotter. This type is called a side jaw clip to distinguish it from the transit and eccentric types, also in frequent use. The transit clip has a flat base plate punched with five bolt holes in a line not quite at right angles to the axis ot the switch rod when the clip is in place on the rod, long, with ends upset ⅜ in. to form stops for the heels of rail braces, while two sections of steel bar ½ in. by 6 in. are riveted across the plate at the correct distances from the center of the track to hold the inside flanges of the rails to gage. The gage plate is punched with four holes for spikes to hold it to the tie between the rails as well as with three



Three Throw Split Switch
The St. Louis Frog and Switch Manufacturing Co.



Three Rail Split Switch
The Wier Frog Co.

where it is held by means of a vertical threaded bolt under a top strap fastening. These holes at differing distances from the center of the rod provide adjustment in length, ranging from ⅛ in. to ½ in., effected by moving the bolt from one hole to another. The eccentric clip differs from the transit clip chiefly through the substitution of an eccentric washer for the adjusting device, which washer is placed between the base of the clip and the top strap fastening, and may be turned so as to move the clip slightly in relation to the center of the rod. All switch ties from the head block to the heel of the frog are commonly provided with tie plates, preferably special plates long enough for the switch rails to move on, known as slide plates. Heel plates or tie plates long enough to accommodate the rails in both the parent and turnout tracks on ties behind the heel of the frog but too close together to be placed on separate ties are also generally used with switches.

The running rails are frequently held rigidly in place on the tie which bears the switch points or on the first tie ahead of the points, by means of a steel gage plate, usually ¾ in. by 6 in. by about 6 ft. holes for spikes to hold each rail. A gage plate designed to support switch points is furnished with riser plates, which are slide plates with raised ridges for central areas on which the switch rail bears directly when thrown against the stock rail, to bring it to the desired elevation.

A. R. E. A. Specifications for Switches*

43. The throw of the switch shall be 5 in. at the center line of the No. 1 rod.

44. The gage of the track shall be 4 ft. 8½ in.

45. Side planing and bending of switch rails shall conform to a spread at the heel of 6¼ in. between the gage lines of the stock rail and the switch rail and a thickness of ¼-in. at the point. The bending and planing shall be done so as to give a straight gage line to the switch rail. The switch rail shall afterward be ground down to a thickness of ⅛-in. at the point, beginning 2 ft. back from the point of the switch; the point of the switch shall then be ground down to a sharp edge with a radius of 1½ in. The head of switch rail shall fit neatly against the head of stock rail from point of switch rail to point of divergence. The inner edge of the head of the stock rail and the outer face of the web of the switch rail at the point shall be in the same vertical line when the switch rail is fitted against the stock rail.

*See Specifications for Frog. P. 85.

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46. Top planing shall conform to the measurements shown on Fig. 1 and Table 1.

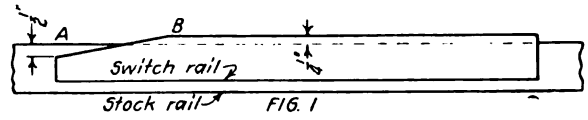
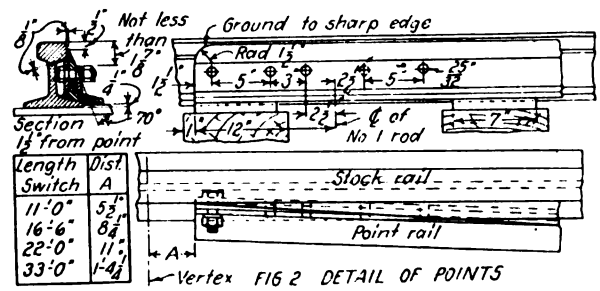


TABLE 1.

Switch	A	B
33 ft.		12 ft.
22 ft.		9 ft.
16 ft. 6 in.		7 ft.
11 ft.		5 ft.

47. The bottom of the switch rail shall be planed to fit neatly on the base of the stock rail where the bases overlap.

48. The point of the switch rail shall be as shown in Fig. 2.



49. Holes for switch rod lugs and stop blocks shall be 25/32-in. in diameter and 5 in. center to center, holes for reinforcing bars being 25/32-in. in diameter. Their number and locations shall be as provided under reinforcing bars.

50. Lugs shall be as deep as the section of rail will permit.

51. The distance between centers of holes for bolts running through the web of the rail shall be 5 in. The diameter of holes shall be 25/32-in. Switch rod bolt holes shall be 1 3/32 in. in diameter.

52. Switch rods shall be ¾ by 2½ in. and shall be held in a horizontal plane. Bolt holes shall be 1 3/32 in. in diameter. There shall be at least 1½ in. of metal at end beyond bolt holes.

53. A reinforcing bar ⅜-in thick shall be riveted to each side of each switch rail and point ends shall be made flush with point of switch rail. The bars shall be as long as the heel connections will permit. Bars shall fit against web of rail and shall fill the space between head and flange of rail. There shall be 1/16-in. clearance between outer bar and head of stock rail where the bar projects under the head of stock rail. The top of the inner bar, where it projects beyond the head of the switch rail, shall not be less than 1⅞ in. below the top of the stock rail. The reinforcing bar shall be beveled to an angle of 45 deg. where it projects beyond the head of the rail.

54. Bars shall be fastened to the rail with ¾-in. rivets except that at the first, second and fifth holes, and the holes through which the lugs are fastened, they shall be bolted. The center of the first hole shall be 1½ in. from the point, and the center of the last hole in the bar shall be 2 in. from the heel end of the bar. Intermediate rivet shall be placed so that there shall be fastenings at intervals not greater than 12 in. bolts

55. Stop blocks shall be of approved design with holes 13/16-in. in diameter. Stop blocks shall be spaced as nearly as practicable at equal intervals between the end of the planing and the heel of the switch.

56. Heel blocks shall be of approved design, with standard rail drilling.

57. Bolts, fastening lugs, stop blocks and footguards to switch rails shall be ¾-in. in diameter. Bolts connecting the lugs with switch rods and the switch-stand connecting bolt shall be 1 in. in diameter and machine turned. All bolts shall be provided with nut-locks and cotters; ¾-in. bolts shall have hexagonal nuts and 1-in. bolts shall have square nuts.

58. Rivets shall have diameters of the full sizes shown on the plan, and the diameters of the rivet holes shall be not more than 1/16-in. greater than the diameters of the corresponding rivets. The rivets shall be of sufficient length to provide full, neatly made heads when driven. They shall be driven tight, bringing all adjacent parts into contact.

59. Rivets, when not countersunk or flattened, shall have standard button heads of uniform size for the same size rivets. The heads shall be full and neatly made and concentric with the holes.

60. When the rivet heads are countersunk they shall be flush with the plate and shall fill the holes.

61. There shall be on each tie two plates of suitable length ⅞-in. by 7-in., planed down to receive the stock rail and braces. Three holes outside and two inside are required for ⅞-in. lag screws or screw spikes or for ordinary spikes as may be specified on all switch ties except the two head ties, where there shall be three outside and five inside, one of the inside holes to be in position for spiking the switch.

62. Braces shall be of such design that 2½-in. clearance for detector bars may be obtained. Three holes for ⅞-in. lag screws or screw spikes shall be provided.

63. Strap foot-guards shall have a minimum thickness of ⅜-in. and shall be fastened to the web of the rail by ¾-in. bolts or rivets.

Slip Switch

A slip switch is a combination of one or two pairs of turnouts and a crossing, each pair of turnouts having a common curved lead and stock rail. The end frogs of the crossing serve as frogs for the turnouts, while the middle frogs are usually movable point frogs, because at acute angles there is not room for wing rails and guard rails and the movable point frog is less liable to cause derailments than a rigid frog.

A slip switch may be single or double, depending on whether access is afforded from either track to the other in one or in both directions. A single slip switch affords a connection across one obtuse angle of the crossing while a double slip switch provides access across both obtuse angles. The end and center switch rails may be operated by means of separate switch stands or from one stand opposite the center, pipe-connected to the end switch rails. Unless interlocked, the latter arrangement is preferable, as it saves time and is more convenient. The number of the slip switch is that of the crossing frogs. The slip switch is a space-saving arrangement used where there is not room for ordinary turnouts, as in tracks crossing a number of parallel yard tracks diagonally.

Insulated Switch

An insulated switch has the metallic surfaces so separated with non-conductors of electricity that the current carried in a track circuit is confined as desired, usually to one line of running rails. A switch may also be insulated by installing insulated rail joints on each side of it. The insulation is usually of a board-like pressed fibre or wood. Wood insulation is not durable in thin sheets, as it expands and becomes soft when moist. Vulcanized fibre shapes are more generally used for this purpose,

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witch

Tangent Adjacent to Switch Rail	Tangent Adjacent to Toe of Frog
Feet	Feet
0.00	0.97
0.00	2.00
0.00	0.22
0.32	0.00
0.00	0.57
1.56	0.00
2.99	0.00
5.33	0.00
0.00	2.84
0.00	0.51
0.00	0.40
0.00	6.38
0.00	0,27

LEADS
rve

Distance P.C. to Theoretical Point of Frog
Feet
47.08
56.51
65.92
75.33
84.75
94.17
103.59
113.00
131.83
141.25
150.67
169.50
188.33

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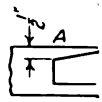
Switch

46. To
shown on



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22
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48. Th
Fig. 2.

Section
1½" from p

Length Switch	Di
11'-0"	5
16'-6"	8
22'-0"	1
33'-0"	1

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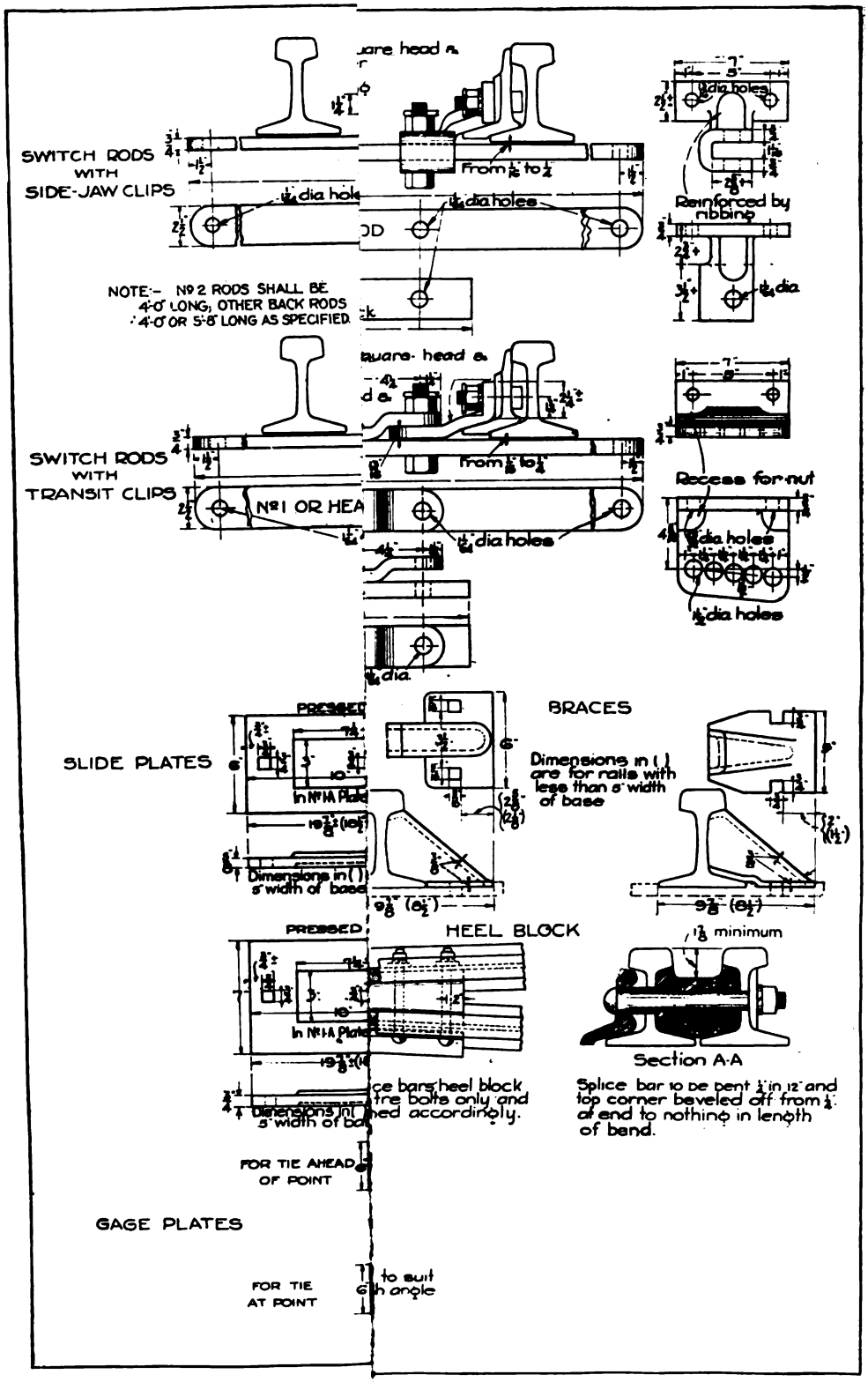

Tangent Adjacent to Switch Rail	Tangent Adjacent to Toe of Frog
Feet	Feet
0.00	0.97
0.00	2.00
0.00	0.22
0.32	0.00
0.00	0.57
1.56	0.00
2.99	0.00
5.33	0.00
0.00	2.84
0.00	0.51
0.00	0.40
0.00	6.38
0.00	0,27

LEADS

Distance P.C. to Theoretical Point of Frog
Feet
47.08
56.51
65.92
75.33
84.75
94.17
103.59
113.00
131.83
141.25
150.67
169.50
188.33

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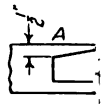

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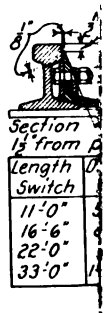

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TABLE OF PRACTICAL SWITCH LEADS

Frog Number	Length of Switch Rail	Lead = Distance Actual Point of Switch Rail to Frog ½" Point	CLOSURE RAILS — Number of Rails and Lengths in Feet and Inches				LEAD CURVE		GAGE LINE OFFSETS						Tangent Adjacent to Switch Rail	Tangent Adjacent to Toe of Frog
			Straight Rail		Curved Rail		Radius of Center Line	Degree of Curve	X	X_1	X_2	Y	Y_1	Y_2		
	′ ″	′ ″					Feet	° ′ ″	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In	Ft. In.	Feet	Feet
5	11-0	42-6½		1—28-0	1—28-3¾		175.40	33-07-28	17-11	24-10	31-9	0-11⅝	1- 8 4/16	2- 8 4/16	0.00	0.97
6	11-0	47-6		1—32-9	1—33		254.00	22-42-20	19- 2¼	27- 4½	35-6¾	1- 0 4/16	1- 9½	2- 9 11/16	0.00	2.00
7	16-6	62-1	1—26	1—14-10½	1—26	1—15-1½	361.69	15-53-30	26- 8½	36-11	47-1½	0-11¾	1- 8 11/16	2- 9⅛	0.00	0.22
8	16-6	68-0	1—30	1—16-5	1—30	1—16-7	487.37	11-46-36	28- 1¼	39- 8½	51-3¾	1- 0 7/16	1- 9 8/16	2- 9⅝	0.32	0.00
9	16-6	72-3½	1—33	1—16-5	1—33	1—16-7	605.18	9-28-42	28- 9	40-11¾	53-2¼	1- 0¼	1- 9⅛	2- 9	0.00	0.57
10	16-6	78-9	1—28	1—27-10	2—28		779.82	7-21-08	30- 3⅜	44- 0⅝	57-9¾	1- 0 7/16	1- 9 7/16	2- 9⅜	1.56	0.00
11	22-0	94-3¾	1—33	1—32-10¼	2—33		922.65	6-12-47	40- 8⅞	56- 5⅝	72-2¼	1- 0 12/16	1-10 1/16	2-10 7/16	2.99	0.00
12	22-0	100-9⅝	2—24	1—23-10⅝	3—24		1098.73	5-12-59	43-11⅞	60- 7¾	77-3⅜	1- 1 2/16	1-10 2/16	2-10 2/16	5.33	0.00
14	22-0	106-3¼	2—30	1—16-5¼	2—30	1—16-6¾	1512.14	3-47-23	41- 1¼	60- 2½	79-3¾	1- 0 12/16	1-10½	2-10 12/16	0.00	2.84
15	30-0	126-2¼	2—30	1—27-10¾	2—30	1—28	1748.29	3-16-40	52- 0	74- 0	96-0	1- 0 7/16	1- 9 11/16	2-10 3/16	0.00	0.51
16	30-0	131-6¾	2—30	1—32-10¾	2—30	1—33	2019.18	2-50-16	53- 2¾	76- 5½	99-8¼	1- 0½	1- 9 12/16	2-10 5/16	0.00	0.40
18	30-0	138-6	2—33	1—32-11	3—33		2380.47	2-24-26	54- 8¾	79- 5½	104-2¼	1- 0¾	1-10 4/16	2-10 12/16	0.00	6.38
20	30-0	151-5½	2—33 1—30	1—14-11½	2—33 1—30	1—15-0½	3322.13	1-43-29	57-9	85-6	113-3	1- 1 4/16	1-10 12/16	2-11 7/16	0.00	0.27

TURNOUTS AND CROSSOVERS RECOMMENDED

For Main Line High Speed Movements, No. 20 or No. 16.
For Main Line Slow Speed Movements, No. 11 or No. 10.
For Yards and Sidings, to Meet General Conditions, No. 8.

PROPERTIES OF FROGS							PROPERTIES OF SWITCHES		LEADS For P. C. at Heel of Switch and P. T. at Toe End of Frog			THEORETICAL LEADS For Uniform Curve Throughout		
Frog Number	Total Length	Toe Length to ½" Point	Heel to ½" Point	Frog Angle	Toe Spread	Heel Spread	Length of Switch Rail	Thickness of Point = ¼" / Heel Spread = 6¼" / Switch Angle	Radius of Center Line	Degree of Curve	Distance Point of Switch to Theoretical Point of Frog	Radius of Center Line	Degree of Curve	Distance P.C. to Theoretical Point of Frog
	Ft. In.	Ft. In.	Ft. In.	° ′ ″	In.	In.	Ft. In.	° ′ ″	Feet	° ′ ″	Feet	Feet	° ′ ″	Feet
5	9-0	3- 6½	5- 5½	11-25-16	7 1/16	13 8/16	11-0	2-36-19	185.59	31-15-28	42.94	235.42	24-31-28	47.08
6	10-0	3- 9	6- 3	9-31-38	7	13	11-0	2-36-19	280.48	20-32-14	48.41	339.08	16-57-34	56.51
7	12-0	4- 8½	7- 3½	8-10-16	7 8/16	13	16-6	1-44-11	364.88	15-47-19	61.94	461.43	12-26-30	65.92
8	13-0	5- 1	7-11	7-09-10	7⅛	12⅜	16-6	1-44-11	488.71	11-44-40	67.47	602.65	9-31-06	75.33
9	16-0	6- 4½	9- 7½	6-21-35	8 1/16	13 8/16	16-6	1-44-11	616.27	9-18-27	72.24	762.73	7-31-02	84.75
10	16-6	6- 5	10- 1	5-43-29	7 8/16	12⅝	16-6	1-44-11	790.25	7-15-18	77.51	941.70	6-05-14	94.17
11	17-0	6- 5½	10- 6½	5-12-18	6 8/16	12	22-0	1-18-08	940.21	6-05-48	92.06	1139.47	5-01-48	103.59
12	18-6	6-11	11- 7	4-46-19	6 7/16	12⅛	22-0	1-18-08	1136.34	5-02-38	97.25	1355.96	4-13-36	113.00
14	21-6	7-10	13- 8	4-05-27	6 4/16	12 8/16	22-0	1-18-08	1600.73	3-34-48	107.16	1845.64	3-06-18	131.83
15	22-6	8- 3½	14- 2½	3-49-06	6⅛	11⅞	30-0	0-57-18	1764.69	3-14-50	125.87	2118.70	2-42-16	141.25
16	24-0	8- 8	15- 4	3-34-47	6	12	30-0	0-57-18	2032.74	2-49-08	131.15	2410.79	2-22-36	150.67
18	26-6	9- 7	16-11	3-10-56	5⅞	11¾	30-0	0-57-18	2632.76	2-10-35	141.18	3051.10	1-52-40	169.50
20	29-0	10- 6	18- 6	2-51-51	5 11/16	11⅝	30-0	0-57-18	3334.16	1-43-06	150.77	3766.70	1-31-16	188.33

A. R. E. A. Table of Practical and Theoretical Switch Leads

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being laid between the metal surfaces of special joints provided in the centers of switch rods and gage plates, with insulated bushings and washers around the bolts. Insulation should be carefully placed and as carefully inspected for indications of wear or deterioration. Snow and ice interfere with insulation and should be cleared and kept away as thoroughly as possible by maintaining adequate drainage. Salt should not be used to thaw snow or ice from insulated switches, as it deteriorates the insulation, corrodes the metal and is an electrical conductor. Cinders, slag and dirt make poor ballast for insulated switches, as they retain moisture and their conductivity is high. Wooden or insulated steel track gages should be used and metal tools or tapes should not be permitted to lie across the rails of switches with insulated rods, as they will carry the current across the track.

The A. R. E. A. recommends the following lengths of switches:

For all new work, 16½-ft. switch points for frogs over No. 6 up to and including No. 10; 22-ft. points for frogs over No. 10 up to and including No. 14; 33-ft. points for frogs over No. 14 and 11-ft.. points for No. 6 and under where they are required.

Nos. 8, 11 and 16 frogs are recommended as meeting all general requirements for yards, main track switches and junctions; new work should be laid out, so far as practicable, for these three frogs, so as to effect the gradual elimination of frogs of other numbers, lessen the cost of manufacture and decrease the amount of stock carried.

SWITCH, ANGLE OF. The angle included between the gage lines of the parent track rail and the switch point rail. These angles from the points of divergence of turnouts are necessarily acute to avoid abrupt changes in the direction of movement of rolling stock and consequent shock. For turnouts commonly in use, the switch angles varies between 50 min. and 2 deg. 40 min. Even these slight angles in track are distinctly felt on trains traveling at high speeds. It is therefore common practice to restrict speeds of trains over turnouts. The lengths of switches increase as the angles decrease, the more acute angles and longer switch rails being most generally used in high speed track on main lines, while the wider angles and shorter switch rails are suitable for turnouts where economy of track space is of primary importance as in ladder tracks and other yard or industrial tracks.

SWITCH BLOCKING. Wood or metal fillers or spacers used as foot guards, to prevent the feet from becoming wedged between rails.

SWITCH, INSULATED. A switch provided with non-conductors of electricity, such as insulating fibre shapes, to prevent the diversion of current from the designed course of a track circuit.

To accomplish this the switch rods are insulated at the center by means of lap joints protected by insulating fibre shapes between the bolted steel surfaces. The bolts are insulated by fibre collars and the gage plates, where used, are insulated at the center by means of lap or butt joints similarly protected.

SWITCH, INTERLOCKED. A switch operated by means of an interlocking device, instead of the ordinary switch and connecting rod. An advantage of interlocking switches is that several may thus be thrown by power from a common plant mechanically controlling the track line-up with a view to preventing delay, derailments and collisions. See Interlocking (Signal Section).

SWITCH KEY. The key to a padlock or other form of lock used to secure a switch lever in position and prevent tampering with the switch.

The ordinary switch lock is a brass, spring padlock with a short, heavy, round key, which is secured to the switch stand by a twist link chain. All trainmen and maintenance of way foremen are usually supplied with identical switch keys which fit any of the switch locks on the railway. For joint use by two railway companies, switch stands are sometimes supplied with special hasps with one lock on each end, so arranged that the dropping of either end of the hasp by removing a padlock releases the switch. Thus the keys and locks of both companies are usable for the operation of the point switch. See Switch Stand.

SWITCH LAMP. A railway signal lantern set on the top of a switch stand spindle to afford, by means of an illuminating device, surrounded by colored glass lenses, indications of the position of the switch at night to those who are in direct charge of train movements. It performs the same function at night as the switch stand banner in the day time.

A switch lamp consists essentially of a metal case built on a frame enclosing a lamp and having in each of its four sides a circular glass lens of distinctive color. It is also provided with a ventilating device, a top, a lantern handle and a base with a spindle fastening. The lamp is removable and when in place revolves with the spindle. The lenses in opposite walls of the case are of like color, commonly red and green. When the switch is set to indicate proceed, the green lights are designed to be in line with the main track and visible from either direction. When set at danger or stop, the red lights are designed to be in line with the main track and visible from either direction. The illuminant is usually a special grade of oil, or it may be kerosene, signal oil, acetylene, or electricity.

Oil burning switch lamps have illuminating devices similar in principle to the ordinary lantern but modified to serve their special purpose of out-of-doors signals. The lamp is usually about 18 in. high and 9 in. wide, while the burner is only about 1½ in. in diameter; the chimney is a comparatively short, wide cylinder of clear glass; the small wick holder is designed to spread the flame; the wick adjuster is about 4½ in. long, for operation from outside the case, and the large, seamless oil fount holding 16 to 31 oz. of oil, is constructed with a view to minimizing attendance and maintenance.

The trend of development has been also toward such ventilation as will produce a balanced draft in all weather; that is, a balance between the cold air admitted to the lamp and the heated air which rises from the flame and escapes through the ventilator.

The reservoir or oil fount is preferably of pressed metal without seams to prevent leakage. It is accessible from the hinged top or from a side door if the top is fixed. The burner is set at such a height that the flame focuses with the centers of the lenses and is designed to give the flame the desired spread. The wick is usually a cylinder of loosely braided cotton with a soft core of longitudinal cotton fibre

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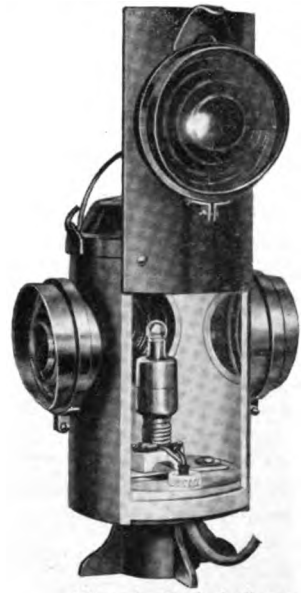
to draw oil readily and prevent incrustation from charring, which reduces the flame. The sprocket shaft is usually extended through the case to permit adjustment of the flame without opening the lamp. The chimney is a cylinder of tough, clear glass, formed with a view to perfect ventilation, which consideration also governs largely the design of all the other lamp parts. To obtain a balanced draft with varying wind velocities, the case is made with curved surfaces, usually cylindrical or globular, and as nearly air-tight as possible except for the draft holes.

The top is a metal cover, usually raised above the body on braces to provide ventilating space and serving the purpose also of flue and smoke jack. It is sometimes hinged and latched to the body and may include a hollow, double-walled, truncated cone of sheet metal provided with suitable perforations for ventilation, surmounted by the circular metal cap.

Lenses are preferably made with smooth, spheroidal outside surfaces to avoid the adherence of snow and moisture which tend to obscure the light. They are made of the clearest and best colored glass, so formed as to concentrate the rays of a small flame to best advantage for the purpose intended, and are called high transmission lenses. While the lens has no effect on the volume of light produced at the wick, it controls the distribution of rays from the lamp, to a narrow beam or a wide path, according to its focus.

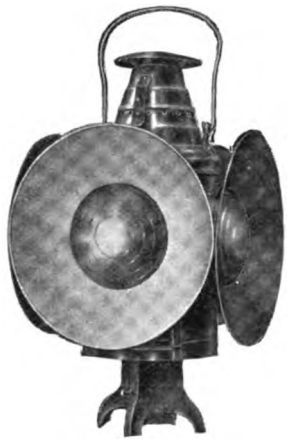
Given the same flames, and lenses of the same design and focal length, the candle power of the lamps will vary in proportion to the areas of the lens. The spread of rays increase as the dimensions of the source of light increase and as the focal decreases. The usual practice in switch lamp manufacture is to set the flame at an angle of 45 deg. with the axes of the lenses, thereby increasing the candle power by about one-fourth.

Adlake Standard Oil Switch Lamp
The Adams & Westlake Co.



Electric Switch Lamp
Peter Gray & Sons
(See Page 700)

Target Oil Switch Lantern
Peter Gray & Sons
(See Page 700)



Dressel Target Reflector Oil Switch Lamp
The Dressel Railway Lamp Works

Handlan Radius Oil Switch Lamp
The Handlan-Buck Manufacturing Co.

Straight Body Oil Switch Lamp
The Armspear Manufacturing Co.

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The long-time burner is designed with a view to perfection of combustion, a consequent maximum beam power and minimum maintenance demand. To minimize attendance the one-day lamps have been largely replaced by long-time burners for use with large capacity oil founts, center core wicks and a grade of oil that gives reasonable assurance of good results with attendance once a week, though semi-weekly inspection is considered desirable and the best practice. The tendency in changing to long-time burners and oil has naturally been to so equip outlying lamps first, while the lamps in locations which could be readily reached, as in yards, were the last to be changed. The jar due to passing trains is minimized by the use of a spiral spring in the lamp base, or by placing the switch stand on a foundation independent of the track ties.

The efficiency of a switch lamp is dependent on the design of the lamp and its parts, on the position of the lamp, on the illuminant used, on atmospheric conditions and on maintenance.

Important features of the switch lamp are the form, color and size of the lenses; the ventilation of the lamp; the prevention of incrustation on the wick; the correct direction of the light rays and the suitability of the illuminant.

The intense concentration of light suitable for a lamp on straight track necessitates a lens, focal distance and candle power which are usually not all suitable for lamps on curved track or for yard lamps, where a wider spread of beam is essential. Prevention of condensation or sweating of the lens depends on the regulation of ventilation to obtain the balanced draft; that is, the entrance of just enough cold air to balance the outgoing hot air; producing a steady draft of cold air down around the outside of the lamp and an equal draft of hot air up the center of the lamp and out of the top.

In order to prevent direct inrushes of cold air, lamp-top casings are dropped to lap over the ventilating rings. The form of the burner and the wick and their relative positions under the ventilating cone and back of the lens are directly related to the ventilating arrangements, as well as to the intensity of the light produced.

The lens has no effect on the volume of light produced at the wick, but is used to control the distribution of the light from the lamp. With different kinds of lenses it is possible to converge all the light from a lamp in a narrow beam, or to give the rays any desired width of diversion. Expert selection of switch lamps to suit the various conditions of service encountered on nearly every railway division is important.

Instruction in the proper maintenance of switch lamps and parts, the care of illuminating oil in storage and its judicious use in the founts of lamps, the periodical inspection of lamps in service with a view to compiling a record of failures and of reducing them to a minimum, are matters which preferably are made the special duties of some employee or officer with authority to proceed along lines of efficiency in the correction of the uses and abuses of these devices so necessary to the maintenance of traffic.

The best of oil switch lamps will get dirty, smoke from the flame tending to obscure the light, coating the lenses on the inside if the wick is turned too high or if an incrustation has charred the end. Dust or snow may also adhere to the outside of the lens and tend to obscure the light, while insects entering the case may lower its effective candle power. The lamp should be placed on the most solid foundation possible, where vibration due to wind and trains will have the least influence. A switch lamp on a tall slender spindle above a target of liberal area will frequently vibrate from the force of the wind alone until the light indication is poor. High target switch stands are commonly made with these contingencies in mind, some types being braced to present vibration. Switch lamps burners are periodically boiled to thoroughly cleanse the parts of all dirt. The fount is not filled entirely full of oil but ¼ in. to ½ in. is left unfilled as an air space. The lamp is lighted and turned low for a few minutes until it has fully responded to the illuminant, when it is regulated to a medium flame.

SWITCH LAMP DISC. See Target, Switch Lamp Lens.

SWITCH LAMP TOP. A circular metal cover carried on the body of the switch lamp, sometimes hinged to provide access to the lighting device, and usually combining the functions of ventilator and smoke jack.

SWITCH LEAD. The distance from the point of the switch to the point of the frog.

Cast Bronze Switch Padlock

Malleable Switch Padlock

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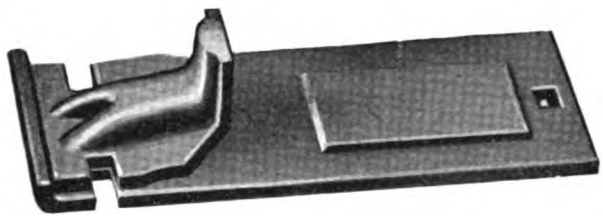
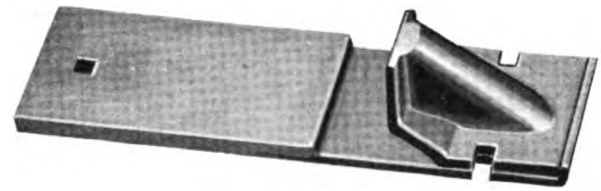
The length of the lead is determined by the frog angle and the angle of the switch.

SWITCH LOCK. A fastener used to lock the switch stand in place and so hold the points of switch rails in the desired position relative to the track; usually a spring padlock. There are in use also various patented switch locking devices, some acting to hold the switch point directly in correct position, by means of docking rods, connecting and acting directly on the switch points independent of the switch rod, or outside the track and parallel to the running rail, or castings connected with the spindle or lever of the stand, as a cam or eccentric casting. (See Page 803 and 825).

SWITCH PLATE. A special tie plate of metal for use on switch ties, each plate being long enough to extend not only under the stock rail and stock rail brace, but also under the switch rail in its position of greatest throw. Switch plates are furnished in sets, to correspond with the length and throw of the switch and the number of switch ties, there being two plates for each tie. See Switch.



Switch Plate and Rail Brace

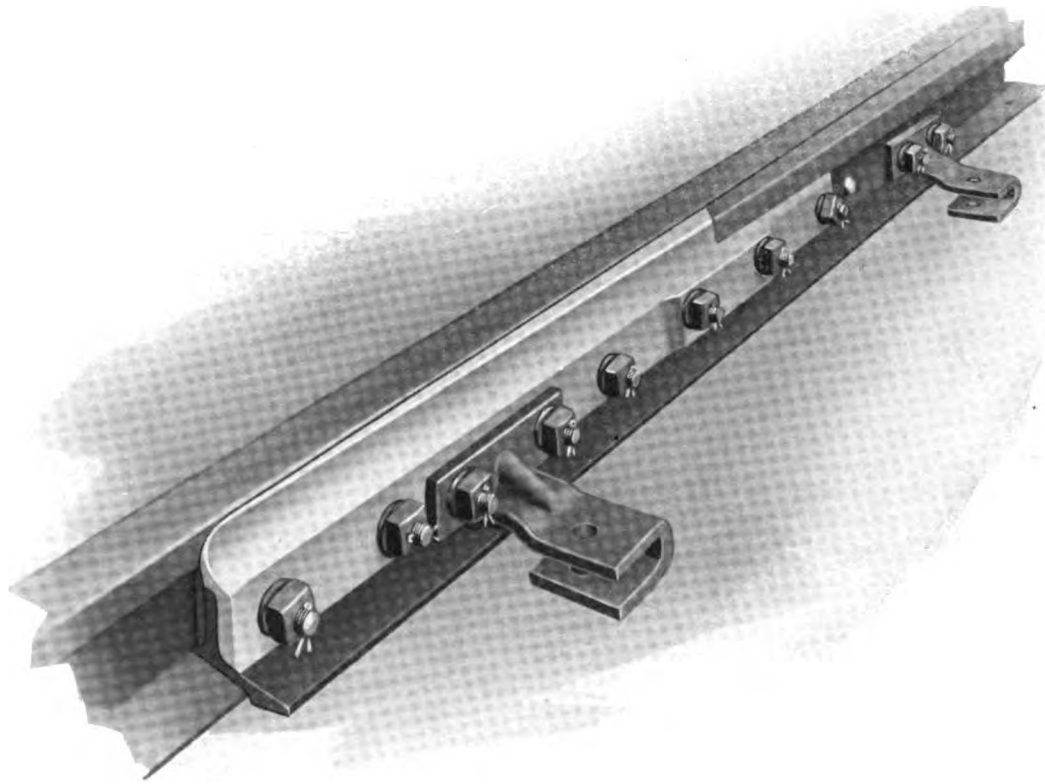


Switch Plate and Rail Brace

SWITCH PLATE, DOUBLE SHOULDER. A switch plate provided with two bearing ridges or two lines of projections above the plane of the plate, one serving as a brace for the outside flange of the stock rail to hold it to gage and another acting as a stop for the foot of the switch rail brace.

SWITCH POINT. The point from which a turnout diverges from the parent track. See Actual Point of Switch. Also Switch Point Rail.

SWITCH POINT, ADJUSTABLE. A pointed steel bar shaped to the form of a switch point from 3 ft. to 7 ft. long with suitable fastenings for attaching it in place of the planed point of a split switch rail.



Manard Switch Point
The Bethlehem Steel Co.

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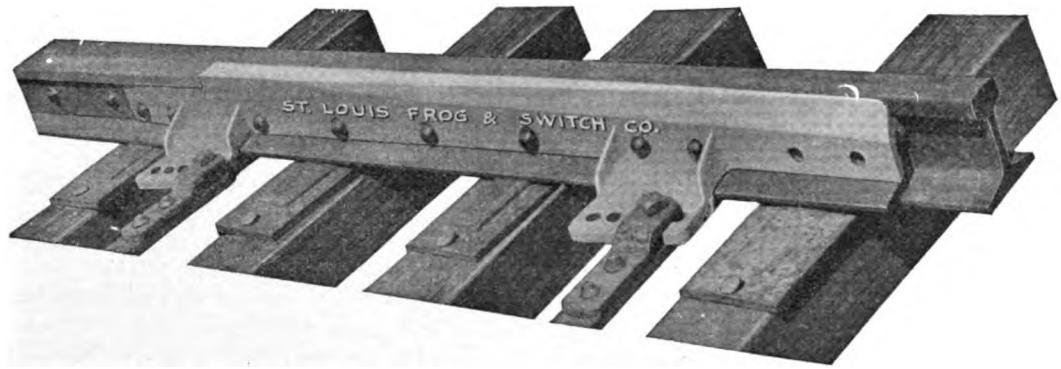
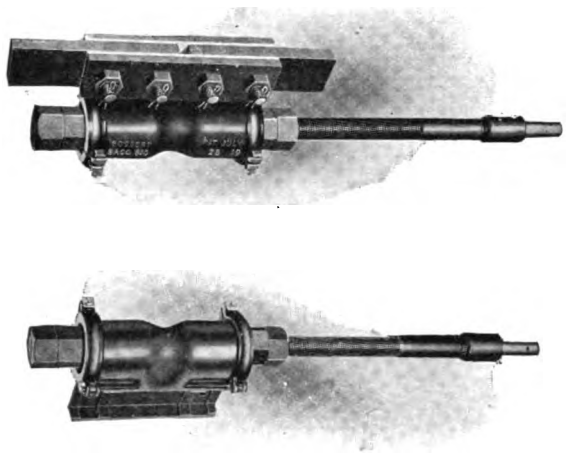
Economy Separable Switch Point
The Louisville Frog & Switch Co.



Manganese Steel Tip with Integral Adjustable Lugs
The St. Louis Frog & Switch Co.



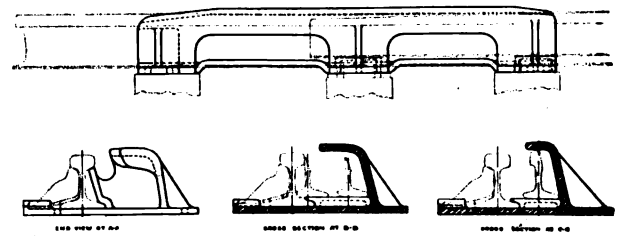
Switch Point Adjuster
The Signal Accessories Co.
(See Page 803)

Adjustable points are made of carbon or alloy steel and are used for the purpose of increasing the service life of switch rails the points of which wear out faster than the heel portions.

SWITCH POINT HOUSING. A recess provided in the gage side of the head of the turnout stock rail at the vertex to give a firm, true bearing for the point rail of a split switch.

The housing is provided by kinking the stock rail or chipping the side of the rail head or planing a strip of metal from it. Chipping is not considered good practice because of the danger of injuring the rail, because it is a slow process and because the surface cannot be made smooth. Planing or kinking is more generally approved.

SWITCH, POINT OF. The point from which a turnout begins.



Switch Point Housing
The Positive Rail Anchor Co.

SWITCH POINT RAIL. One of the two rails of a split switch.

SWITCH POINT REINFORCING BAR. A long metal bar or strap fitted and riveted to the web of a switch point rail to strengthen and stiffen it.

SWITCH POINT STRAIGHTENER. A steel clamp and wedge device used to straighten bent switch points without removing them from the track.

The clamp, which is roughly hook-shaped, is designed to fit over and around both the stock rail and the bent switch rail. At the working end of

Switch Point Straightener
The Maintenance Equipment Co.

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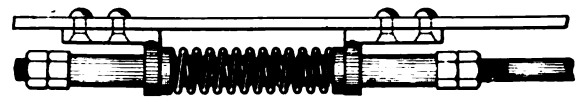
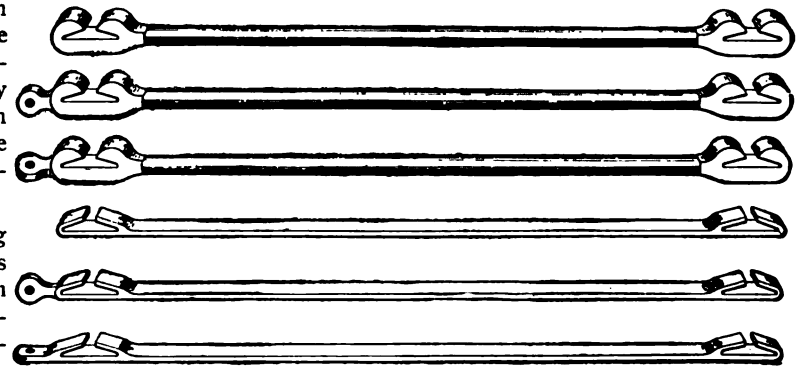
the clamp a lever socket is pivoted on one bolt, while the opposite anchor end is hooked around and beneath the base of the stock rail. When the lever, usually a track bar, is pressed down, the switch rail is bent toward the stock rail with the wedge placed nearer the heel of the switch than the clamp, affording a fulcrum. By means one person may, in one or more operations, restore a bent or twisted switch point to its original condition without taking it out of the track. The special field for this device is the emergency repair of switch points bent by trains traveling through switches which are set against them, the bending of the point endangering traffic from the opposite or facing point direction.

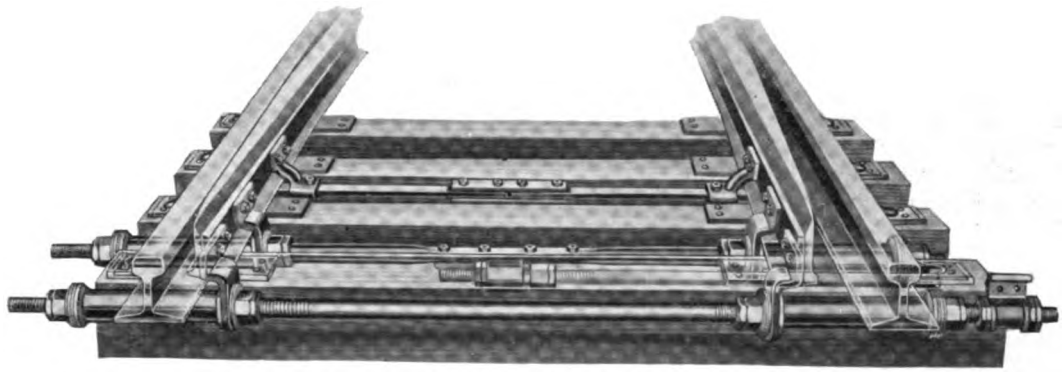


Spring Head Rod
The Morden Frog & Crossing Works

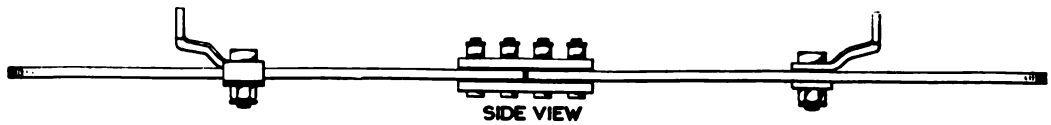


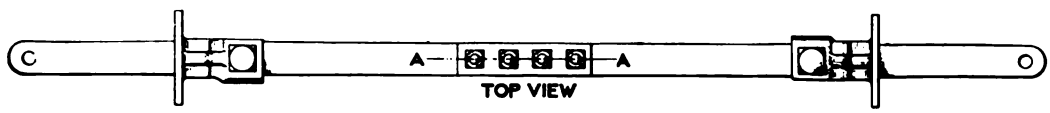
Bridle Switch Rods

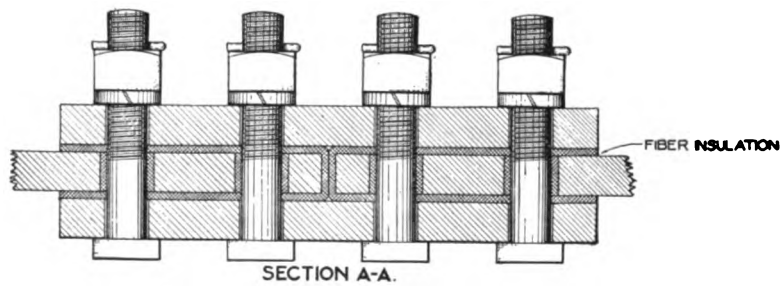
SWITCH ROD. An iron bar having clips or connections near or at its ends to fit the flanges or webs or the two switch rails to hold them in correct relative positions. To perform this function accu-



Wharton-O'Brien Insulated and Adjustable Switch Rods
Wm. Wharton, Jr., & Co., Inc.
(See Page 838)







Insulated Rods for Split Switch
The St. Louis Frog & Switch Co.

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rately the switch rod connecting the points is usually furnished with an adjustment which permits of slight alterations in length. This rod is also extended and drilled to fasten to the connecting rod of the switch stand. When used in a track circuit the switch rods are insulated at the track center.

SWITCH ROD, No. 1. The switch rod nearest the point of the switch. It is placed preferably at the standard distance of 12 in. back from the points of the switch rails, excepting interlocked switches, where it may be placed 17 in. from the points. See Switch.

SWITCH ROD, ADJUSTABLE. A switch rod supplied with an attachment by means of which its length may be altered to maintain the switch rails in their proper positions relative to the running rails. See Gage (of Track).

SWITCH ROD, BACK. A switch rod placed between the No. 1 switch rod and the heel of the switch to help hold the switch rails in their correct relative positions. Back rods are numbered consecutively from the No. 1 rod toward the heel of the switch. See Switch Rod.

SWITCH ROD CLIP. A metal casting by means of which the switch rod is riveted or bolted to the switch rail. See Switch.

SWITCH, SLIP. A multiple track crossover used principally in switching yards to save space in obtaining access from a lead track to a series of parallel tracks, in one or both directions.

Movable point frogs are favored for the obtuse angles and rigid frogs for the acute angles of the crossover. Between the end frogs the tracks are connected by split switches facing in opposite directions and connected by curved rails.

For convenience all the switches of a slip set are commonly operated by means of one pipe connected throwing device. See Switch.

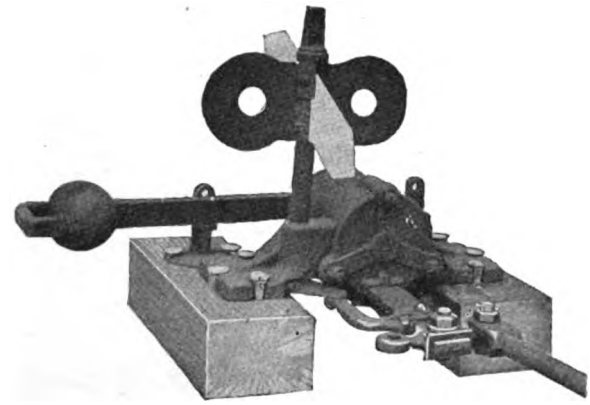
SWITCH, SPLIT. A track turnout device consisting essentially of a movable pair of opposite tapering rails connected by cross rods and placed with their points at the convergence of tracks and between the stock rails, while their full section heel ends are joined to the lead rails of the diverging tracks. The points are less than the gage distance apart and the rails are not spiked but are free to move sidewise so that when one point is against the inside of adjacent stock rail its mate stands inside the opposite running rail and clear of approaching wheels which are diverted by means of the closed point to the track thus made continuous. See Switch.

SWITCH STAND. An operating device by means of which a switch is thrown, locked, and its position indicated for the information of those in direct charge of train movements.

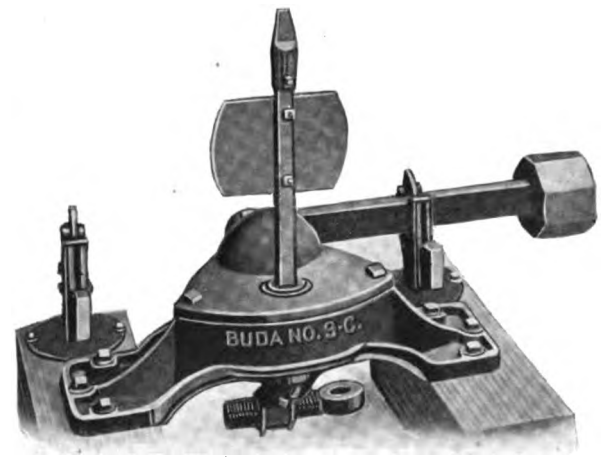
A switch stand consists essentially of a base, a spindle, a lever and a connecting rod. It is usually furnished with lamp and banner signals and a spring padlock, and is spiked on the headblock at the standard distance of 4 ft. 7 in. in the clear from the nearest running rail. It controls the movements of the switch rails by means of a connecting rod one end of which is attached usually to a crank at or near the bottom of the spindle while the other end is fastened to the No. 1 switch rod.

Many styles of switch stands are in use, the principle types being distinguished by their heights, as the housed, jack-knife, ground throw, low, high and ladder switch stands.

The housed stand has a lever which moves in a vertical plane, about a fulcrum placed below the surface of the ground, so that when the lever is dropped into the horizontal position the switch stand may be covered with a lid supplied for the purpose, or there may be an open lever channel in the fixed lid which sets level and flush with the surface



Odenkirk Low Switch Stand
The Cleveland Railway Supply Co.



Buda Low Switch Stand
The Buda Co.
(See Page 660)

of the ground or pavement. This type of switch stand is specially adapted for use in paved streets.

A jack-knife switch stand consists essentially of three parallel horizontal bars of steel, usually about 3 ft. long and placed at right angles to the track on the headblock of the switch, the outside bars forming a fixed frame between the sides of which the middle lever may be moved in a vertical plane, around a fulcrum formed by a rivet or bolt which

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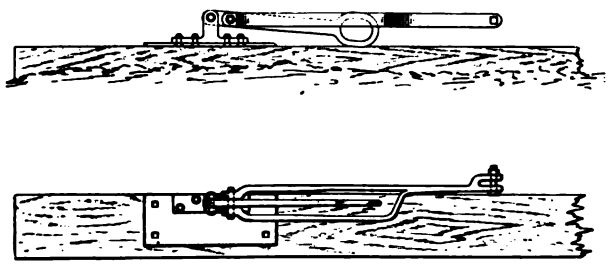
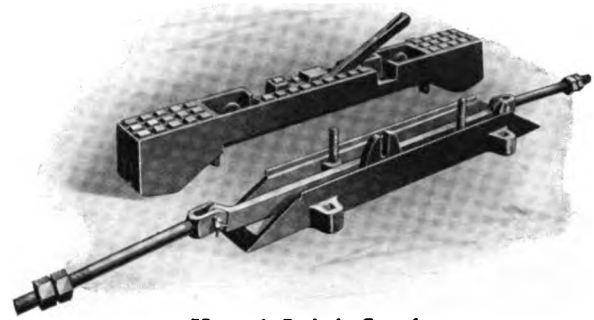
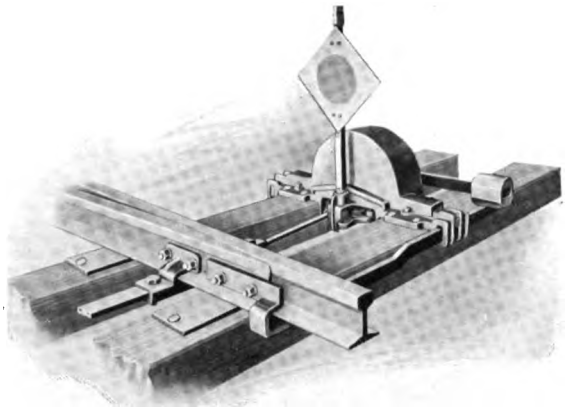


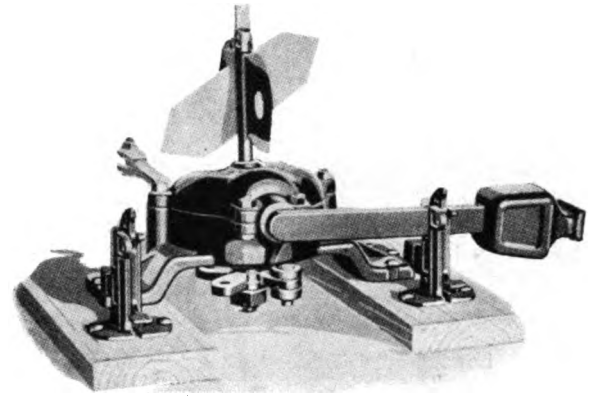
Jack Knife Switch Stand
The Morden Frog & Crossing Works



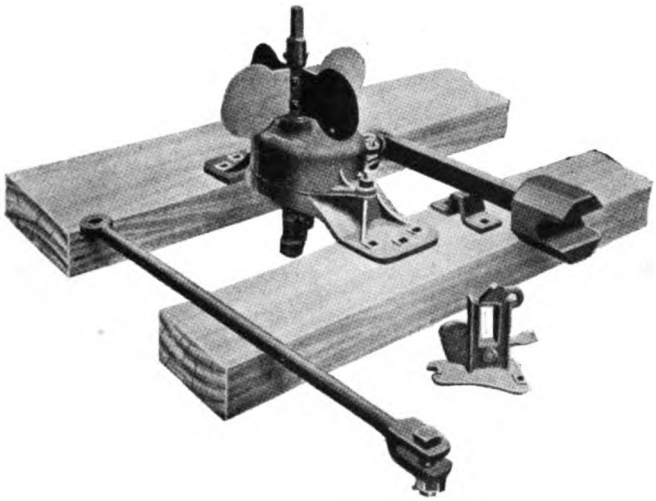
Housed Switch Stand
The Morden Frog & Crossing Works



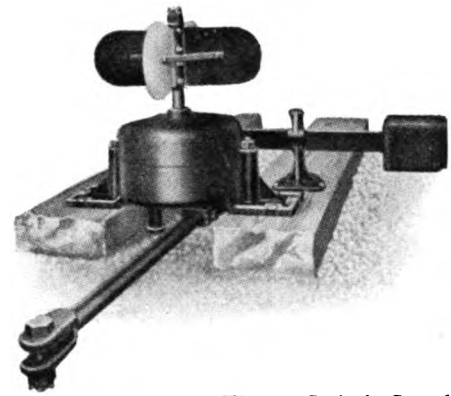
No-Rek Ground Throw Switch Stand
The Morden Frog & Crossing Works



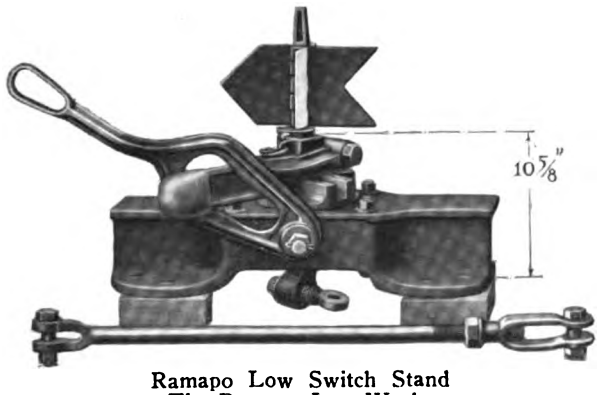
Anderson Economy Switch Stand
The American Valve & Meter Co.



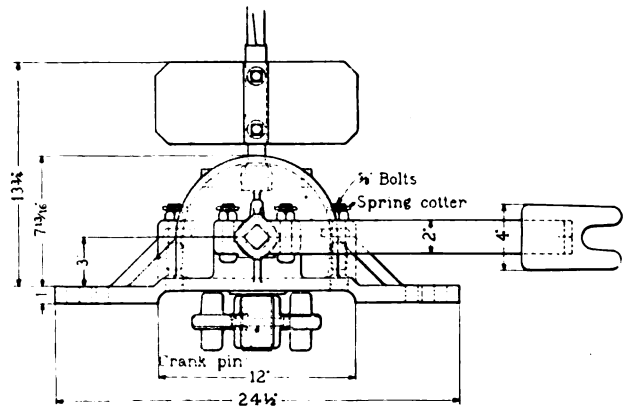
Parallel Throw Ground Switch Stand
The Ajax Forge Co.



Automatic Ground Throw Switch Stand
The Wier Frog Co.



Ramapo Low Switch Stand
The Ramapo Iron Works
(See Page 784)



Low Switch Stand
The Pettibone Mulliken Co.
(See Page 773)

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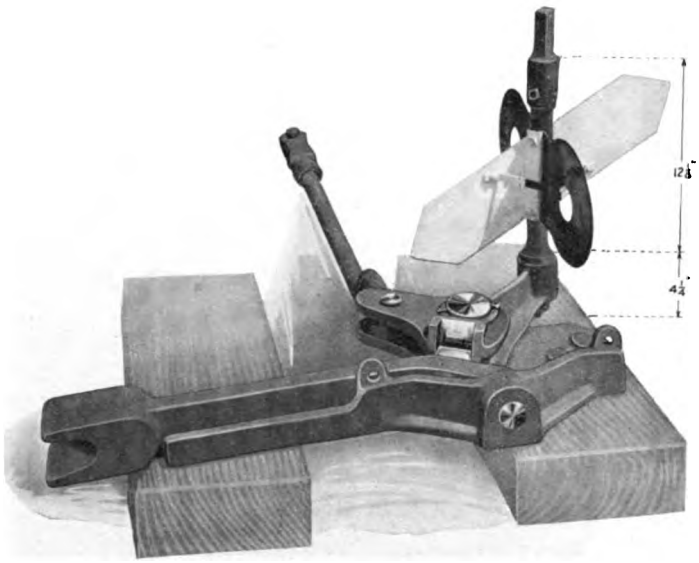
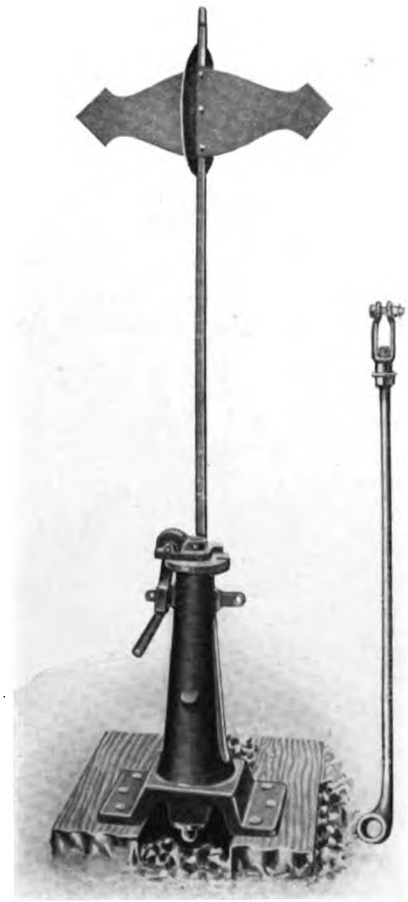
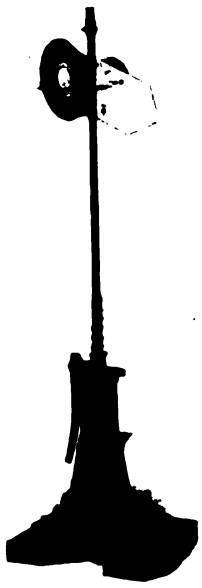


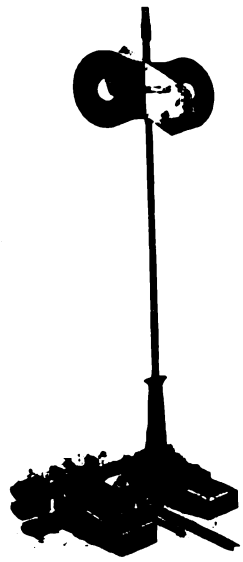
Low Parallel Throw Switch Stand
The Bethlehem Steel Co.



Non-Automatic Switch Stand with Adjustable Throw
The Weir Frog Co.

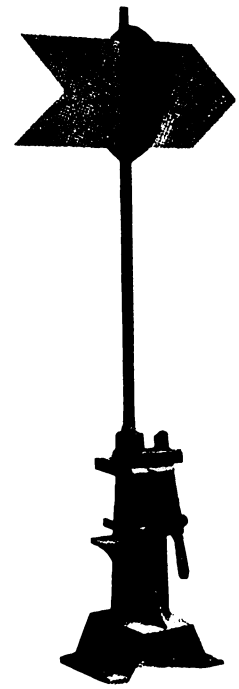


Main Line Safety Switch Stand

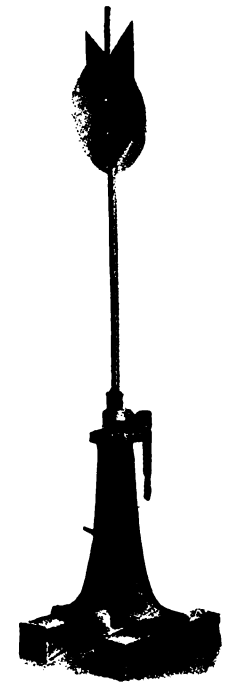


Main Line New Century Switch Stand

The Bethlehem Steel Co.



High Column Switch Stand
The Morden Frog & Crossing Works



Main Line Switch Stand
The Buda Co.
(See Page 660)

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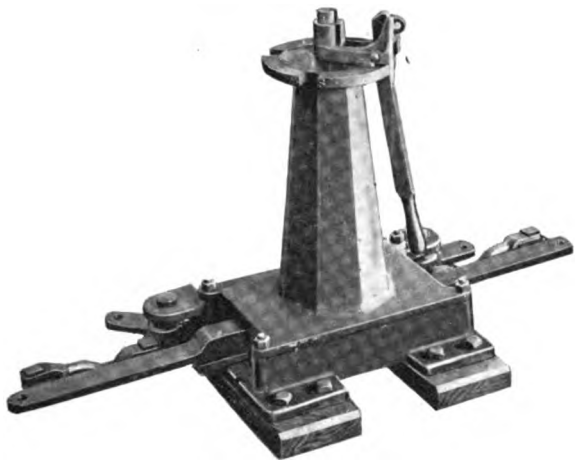
passes horizontally through the frame and the lever about 4 in. from the end of the lever, which is attached to the connecting rod. The throwing of the lever from its closed position in the frame, through an arc of 180 deg. moves its bottom end with the

High Main Line Switch Stand
The Ajax Forge Co.

connecting rod so as to throw the switch. This is a common industrial yard type.

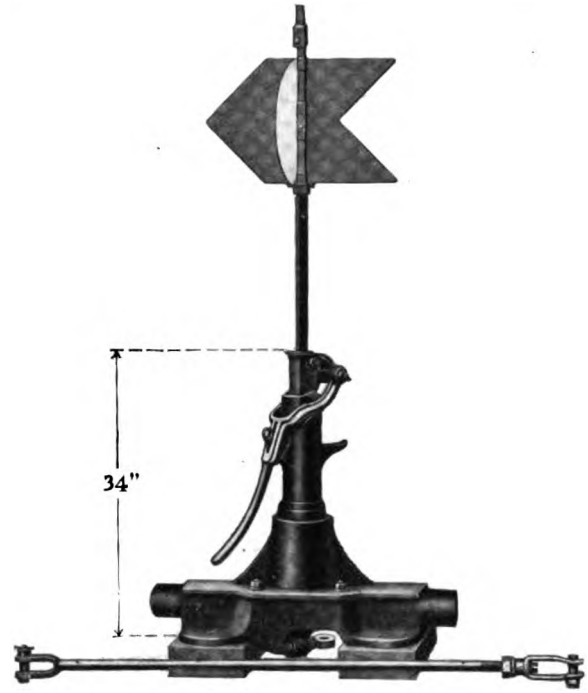
A ground throw switch stand is most serviceable for switching yards and tracks at stations where clearances are restricted and where higher stands are dangerous to employees riding on the sides of cars. It is usually designed to be set between and fastened to two headblock ties. Its lever is usually



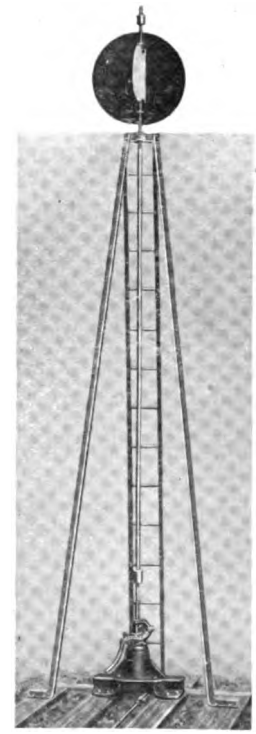
Multiple Four-Way Switch Stand
The Morden Frog & Crossing Works

weighted at the free end and is operated in a vertical plane parallel to the rails. A movement of the lever of 180 deg. from horizontal on one side to horizontal on the opposite side of the stand is necessary to throw the switch points. The crank and spindle joint are usually enclosed in the base casting to protect them against injury and the weather. This is the common yard type.

The low, high and ladder switch stands may differ only in the heights of the spindles which carry the



Automatic High Switch Stand
The Ramapo Iron Works
(See Page 784)



Ladder Switch Stand
The Ramapo Iron Works

signals, which are approximately 4 ft. for low stands, 7 ft. for high stands, and 16 ft. to 20 ft. for ladder stands.

All of these styles may have ground throwing de-

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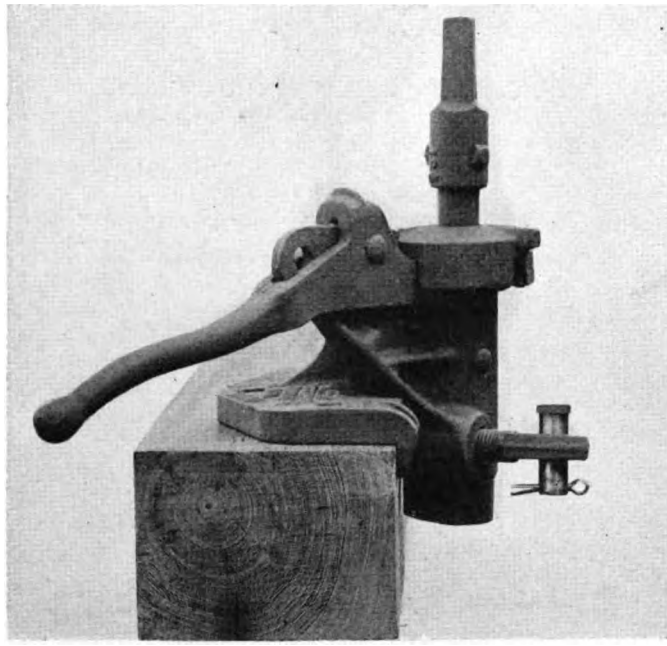
vices, but the style in general use for main track switches is a high stand which has a base casting about 3 ft. high, the top of which is a flat, segmental steel table. The vertical, round iron spindle extends from the track level up through the base casting and the table which supports it, ending at the top in a



Hayes Derail Switch Stand
The Hayes Track Appliance Co.

fitting designed to hold the switch lamp, below which the signal banner is fastened to the spindle. The 7-ft. switch stand is provided with a step on the base casting to permit a lamp tender to reach the switch lamp. A hinged lever is integrally and horizontally fixed to the spindle just above the upper surface of the table. The hinge is at such a distance from the spindle that the lever may be dropped into any one of two or more slots cut in the segmental edge of the table, which are placed to correspond with full throw positions of the switch. The switch stand should be placed so that when thrown for the parent track the connecting rod is in tension.

The base of a switch stand is preferably made of tough metal which will withstand not only the leverage of the throwing of the switch points and the consequent jar of the throwing device, but the last blows from spike mauls struck on the flanges while the spikes are being driven home in the slots to fasten the base to the head block or ties. In maintaining switch stands, frequent inspection and adjustments are required to keep the spindle in the vertical position especially on high main line stands which are set on single timber headblocks. In plumbing the stand and spindle, care is necessary to avoid moving the mechanism in the slightest degree as any deviation from the proper position may throw the lamp fixture, and consequently the switch lamp, out of line with the track so that the path of the light rays will not coincide with the center of the track which the lamp is designed to protect.

The base should be securely spiked, preferably to and between two sides for stability, to minimize the jarring of the lamp due to vibration from passing trains. The spindle should be vertical and so turned that in operating positions the signal indications will be at right angles to the line of sight of enginemen on approaching trains. If possible, the stand should be set on the engineer's side of the track, so that he may have the best possible view of it. Switch stands are commonly made to operate single throw or three throw switches; for double slip switches they are made to operate four ways, by revolving the lever through the four quadrants of a circular table, the stands being placed opposite the middle frogs and pipe-connected to the end switches.

Cranks, U-shaped bends, cams and gears are devices commonly employed to join the bottom of the spindle and the connecting rod in such a way as to throw the switch when the lever is moved. Some cranks are made of breakable metal to permit wheel flanges to trail through the switch without damaging the points. A common form of breakable crank is a flat, symmetrical double ended casting with a bolt hole in each end and a collar in the middle designed to fit over and fasten to the bottom end of the spindle. The connecting rod is attached to either end of the casting. If one end breaks, the connecting rod may be attached to the unbroken end. Some cranks are provided with threaded eye bolts and sockets or turnbuckle adjustments to control the length of throw of the switch.

A. R. E. A. standard practice includes the following requisites for switch stands:

(1) There should be no lost motion in parts.
(2) Stands should have an adjustable throw on the foot.
(3) The operating lever of ground stands should work parallel with the track.
(4) Throwing apparatus should be so arranged that when the switch is set for the movement of a train, it will be thrown to an extreme position and the throwing rod be locked independent of the latch on the stand lever.
(5) The stand should be snowproof.
(6) The connection between the throwing rod and the stand should be so arranged that it will be impossible to separate the throwing rod from the stand when the stand is set up in working position.
(7) The stand should be so arranged that it can be easily inspected.
(8) The target should not show a clear signal for main track movements unless the points are up snug against the stock rail.

SWITCH STAND, FOUR-WAY. A switch stand which may be operated in all of the four quadrants of a circle to control the movements of four switches. See Switch, Slip.

SWITCH STAND, GROUND THROW. A switch operating device in which the fulcrum of the throwing lever is at the base. The ground throw stand usually operates parallel with the tracks in switching yards where space is restricted and higher stands are dangerous to employees riding on the sides of cars. Ground throw switch stands are usually furnished with weighted levers and latches which engage the lever but are entirely separate from the stand.

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SWITCH STAND, HOUSED. A ground throw type of switch operating device enclosed in a metal box set flush with the paving, having a removable top, or a cover with an open lever channel, designed for use in paved streets.

SWITCH STAND, LADDER. A switch stand with a spindle usually 16 to 20 ft. high to permit the switch signals to be seen above obstacles in the line of sight, necessitating a ladder attachment for use of switch lamp inspectors and maintainers. A ladder switch stand may have any height of throwing device, depending on the height of the lever attachment.

SWITCH STAND LEVER. A bar or handle, usually hinged, which is attached to a switch stand spindle for the purpose of throwing and controlling the movements of switch points. See Switch Stand.

SWITCH STAND, LOW. A switch stand with a spindle only high enough to make room for the throwing mechanism, the target and the lamp.

SWITCH STAND, PONY. See Switch Stand, Low.

SWITCH STAND SLEEVE. A tubular metal casting inside which the spindles of some styles of switch stand revolve.

SWITCH STAND SPINDLE. The metal mast or vertical bar to which the crank or connecting rod, the lever, the target and the lamp are attached and with which they move.

SWITCH, STUB. A switch consisting of a pair of movable full-section rails with ends cut square across and joined to the parent track rails at the ends farthest from the frog, while the square cut free ends may be thrown into line with the fixed rails of either the parent track or turnout track, the one movable and two fixed rail ends being held in place on a head shoe or chair. The arrangement of rods and stand does not differ from that of the split switch, which has now largely superseded the stub type. See Switch.

T

TARGET, SWITCH LAMP LENS. A circular flaring collar of enameled iron, of the same color as the lens around which it is fitted and used as a day signal in place of the ordinary target. The four lens targets of a switch lamp are made as large as their positions around the lenses permit, so that their circumferences almost touch when in place.

TARGET, SWITCH STAND. A visual day signal fixed as nearly as possible to the top of the spindle of a switch stand to indicate to those in immediate care of train movements the position of the switch.

There are many styles of switch stand targets, all designed to indicate the position of the switch points. Targets are usually of sheet iron, bolted, riveted or strapped to the spindle near the top and painted with signal colors. They are made in various shapes and sizes. Probably the most simple is a circular red target about 24 in. in diameter for the danger indication with no signal for clear. When this target shows red the points are set for the siding and the target is at right angles to or facing the main track. When it is invisible the points are set for the main track, the target is parallel therewith and invisible from approaching trains. Some targets have white banners to indicate clear or proceed, set at right angles to the red banners indicating danger or stop. Banners are of various shapes, the object being to present symbols which are most conspicuous to enginemen or approaching trains.

TEE. See Hold-Down Horn (Frog). Also Frog, Spring Wing Rail.

THROAT BLOCK. See Filler Block.

THROAT OF FROG. The point at which the converging wing rails of a frog are closest together.

THROAT WAY. See Flangeway.

THROW (of Switch). The distance through which the points of switch rails are moved sidewise to bring either point against the stock rail. The usual throw of a switch is 4¾ in. to 5 in., measured at the center line of the No. 1 switch rod. See Switch Stand.

TIE. See Tie, Cross.

TIE BAR. A rod with clips or projections at the ends so formed as to fasten two track rails or switch point rails together and hold them to gage. See Turnout. Also Switch.

TIE, COMPOSITE. A tie, the essential parts of which are composed of two or more materials, usually steel and concrete or mastic, sometimes with wood or other insulating materials under the rail bearings. Common forms are rectangular in section throughout; or consist of a block beneath each rail bearing, with reinforcement extending the entire length of the tie. Various composite ties are in the experimental stage, but none are generally used in America.

TIE, CONCRETE. A cross tie the essential parts of which are composed of concrete shaped for use as ties when reinforced with metal rods or shapes. Concrete is used for ties on steam railways only when reinforced and protected with steel. While many designs have been perfected, the development has been toward those heavily reinforced and protected at the rail bearings by wood blocks, steel, etc. None of the ties of this type now in use have passed the experimental stage, or have come into extensive use.

TIE, CROSS. One of a series of transverse supports (commonly of wood, laid about 12 in. apart on a railway road bed and embedded in ballast), on which are laid the rails to form the track.

The functions of the cross tie are to bind the rails together, to hold them to gage, and to distribute the loads to the ballast.

The number of ties per mile of main track averages approximately 3200, or 20 ties per 33 ft. panel, at which rate ties 9 in. wide support 45.45 per cent of the total rail base area with a similar bearing on the ballast, while the spaces between the ties are 10.8 in. wide. Side track ties usually average 2800 to the mile and are about 7 in. wide.

Wooden cross ties are generally sawed in the form of simple beams of rectangular section 6 in. by 8 in. to 7 in. by 10 in. in section and usually 8 ft. but sometimes 8 ft. 6 in. or 9 ft. long; or they

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are hewed on two parallel faces only to like thicknesses. Half round wood ties are in general use on some foreign railways. While the squared wooden tie is standard on American roads, many designs of substitute ties made of metal or metal and concrete are being used experimentally. Although of various degrees of merit, they are not yet meeting with much favor, as the present cost is generally prohibitive in comparison with the wooden tie.

Early forms of iron cross ties, known as pot sleepers, have been used in Europe and other countries. The pot sleeper consisted of a flat iron tie bar connecting two oval, cast-iron shapes resembling large tureen covers laid with the concave sides down, one casting under each rail bearing. A later design of metal tie was of inverted trough section with claw-shaped ends. This design was largely manufactured in Europe and used there and elsewhere as a pressed steel shape with a corrugated, wedge-key rail fastening. A still later design is the steel I-beam girder tie with a wide bottom flange, which is largely used on one or two roads in this country.

Although metal is not so easily destroyed as wood, any metal shape designed to hold rails to gage under traffic is usually more sensitive to damage from derailed wheels. A wooden tie may be surface crushed and still safe to retain in the track, whereas the same mishap usually dents and bends the metal tie, thereby altering the relative positions of its rail bearings, distorting the gage and rendering the tie unfit for use. The use of metal or composite ties also involves the necessity for insulating them when used in track circuits. Metal and concrete possess less resiliency than wood and are therefore not so suitable under rolling loads and on varying foundations, and though of more permanent materials, such ties are heavier than wood, more machining is required to produce them, special rail fastenings must be provided, and they are not so readily transported, placed or maintained.

Timber of almost any serviceable kind, soft or hard, is used for ties, the railways generally selecting timber cut as near as possible to their own lines to minimize transportation charges. The growing scarcity of timber has led them gradually to go farther afield for tie supplies, to adopt the use of preservatives, to extend the service life, or to make economical use of timbers unsuitable in their natural state, and to apply various devices to restrict the renewal due to mechanical wear. The United States Railroad Administration's specifications list 25 kinds of wood as suitable for ties, some of which include many varieties with widely differing values, such as the oaks, pines, firs, and cypress. The woods available in large quantity and commonly used untreated include the denser grained hard timber and the heart portions of other woods not readily susceptible to preservative treatment, such as the white oaks, gum, maple, elm, sap cedar, sap cypress, sap Douglas fir, sap pine, etc., are commonly used after preservative treatment.

The total normal annual tie requirements of the steam roads of the United States aggregate approximately 125,000,000, of which 100,000,000 are used for renewals in tracks under traffic and the balance in the construction of new tracks. Approximately 35,000,000 of these ties are treated, of which 75 per cent are hewed and 25 per cent are sawed.

The service life of ties in general depends on the nature of the wood, the method of treatment, if any, the severity of the service, the nature of the mechanical protection afforded, the climatic conditions, etc. Humidity and high temperatures are favorable to parasites which induce wood decay, and therefore tend to shorten the service life of ties to less than half that attained in high, dry climates. The average life of ties in use in all tracks of American railways is between six and seven years. It has been estimated that 25 per cent are removed because of mechanical wear and 75 per cent due to decay. It is highly probable, however, that mechanical wear is wholly or partly responsible for the removal from the track of much more than 25 per cent of the ties, for wear generally precedes and promotes decay.

Rail cutting and spike killing cause disruption of the wood fibres, expose the interior of the wood structure to the spores of parasites and so tend to hasten decay and shorten the life of the tie. Rail cutting, which is especially destructive, is minimized by the use of tie plates, which increase the bearing area of the rail and tend to hold it upright and to gage on the tie. Spike killing also is remedied in part by the use of tie plates and improvement of drainage which reduce the necessity for regaging and the frequent redriving of spikes. The use of switch points to make closures while relaying track, frequent changes of shims in winter and redriving spikes in the new holes rather than in plugged holes are examples of poor practice, causing the weakening of the tie under the rail base. Efforts to overcome this destruction has led to the use, to a limited extent, of screw spikes and other fastenings less destructive than the cut spikes with a view to prolonging the life of ties. The holes for screw spikes, being commonly made before the tie is treated, afford extrance for the preservative into the wood structure so that the subsequent screwing home of the spike in the impregnated tie does not injure the wood, while the fibre-crushing effect of the driven spike is eliminated and the holding-down power is increased. Rail anti-creepers also minimize the distortion of the track structure which tends to displace the spikes, slew the ties and abrade the wood.

Decay which tends to gradually break down the wood structure and destroy its power to withstand mechanical wear results generally from the growth of parasitic plants whose minute seeds or spores fall on the wood, enter the fibrous structure, grow by spreading out filaments which feed on the wood cells and cause the breaking down of their walls and the destruction of the timber, which is left dry, brittle and lifeless. As an antidote to these ills of tie life, the wood is impregnated with chemical preservatives which are poisonous to spores or which provide waterproof coating or both. Creosote and zinc chloride are most widely used, while sodium fluoride is receiving some recognition as a wood preservative. Crosote is effective as a waterproof coating and a poison, while zinc chloride is poisonous to spores but tends to leach out with moisture unless

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combined with some waterproofing chemical such as creosote.

It is not necessary nor usually advisable that the entire section of the tie be impregnated, but all the faces should receive the chemical preservative. Therefore any framing, adzing, or hole boring is preferably done before the tie is treated, and it should not be cut so as to expose the untreated interior wood thereafter. Creosoted ties are placed in close piles until ready for use in order to minimize checking and evaporation of the preservative. Ties treated with zinc chloride should be protected against moisture as well as possible, as they render the best service in dry climates, where there is least tendency of the preservative leaching out of the wood structure.

Present American practice favors the machine adzed, chemically treated tie and the scientific methods of production, inspection, seasoning, treating, handling, installing and renewing, all of which tend toward conservation of the timber supply which is so necessary to the continued annual yield. Future demand, however, will probably not be supplied indefinitely without extensive reforestation.

Within the past few years the center of cross tie production in the United States has moved from the central southern states which have produced oak and pine to the far northwest from where Douglas fir ties are now being obtained.

Specifications for Cross Ties (U. S. R. A.)

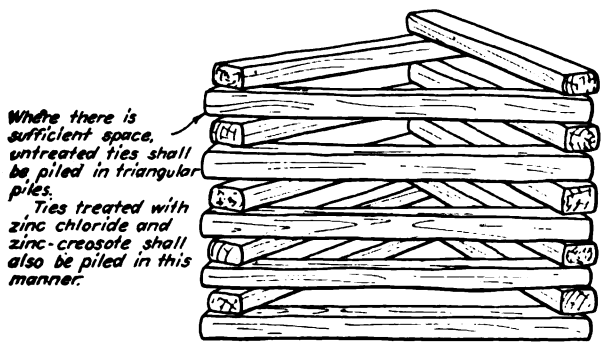
Kinds of Wood. Ash, Beech, Birch, Catalpa, Cedar, Cherry, Chestnut, Cypress, Elm, Fir, Gum, Hackberry, Hemlock, Hickory, Larch, Locust, Maple, Mullberry, Oak, Pine, Redwood, Sassafras, Spruce, Sycamore and Walnut. Others will not be accepted unless specially ordered.

Quality. All ties shall be free from any defects that may impair their strength or durability as cross ties, such as decay, splits, shakes, or large or numerous holes or knots.

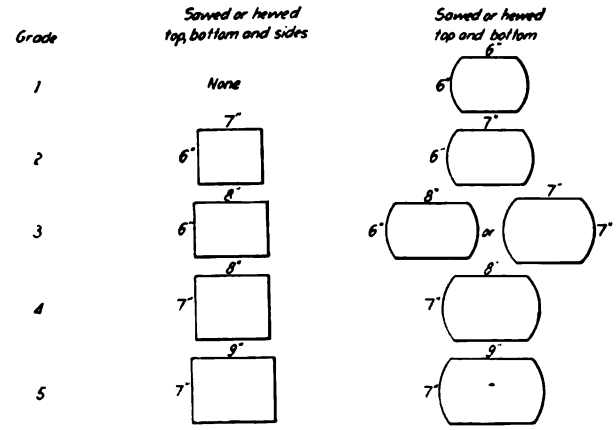
Ties from needle leaved trees shall be of compact wood, not less than one-third summerwood when averaging five or more rings of annual growth per in., or with not less than one-half summerwood in fewer rings, measured along any radius from the pith to the top of the tie. Ties of coarse wood, with fewer rings or less summerwood, will be accepted when specially ordered.

Ties from needle leaved trees for use without preservative treatment shall not have sapwood more than 2 in. wide on the top of the tie between 20 in. and 40 in. from the middle, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

Manufacture. Ties should be made from trees which have been felled not longer than one month.



U. S. R. A. Triangular Method of Piling Untreated Cross Ties



Dimensions of U. S. R. A. Standard Cross Ties

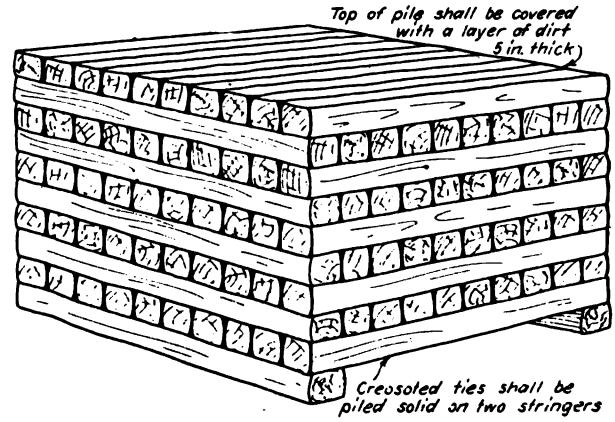
All ties shall be straight, well manufactured, cut square at the ends, have bottom and top parallel, and have bark entirely removed.

Dimensions. All ties shall be eight (8) ft. or eight (8) ft. six (6) in. long.

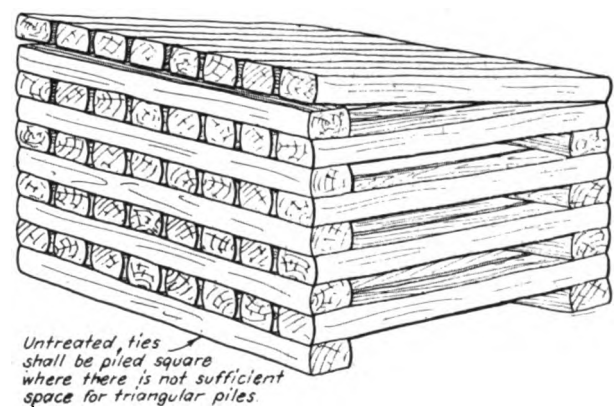
All ties shall measure as follows throughout both sections between 20 in. and 40 in. from the middle of the tie:

The above are minimum dimensions. Ties over one inch more in thickness, over three inches more in width, or over two inches more in length will be degraded or rejected.

The top of the tie is the plane farthest from the pith of the tree, whether or not the pith is present in the tie.



U. S. R. A. Standard Method of Piling Treated Cross Ties



U. S. R. A. Rectangular Method of Piling Untreated Cross Ties

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Delivery. All ties should be delivered to a railroad within one month after being made.

Ties delivered on the premises of the railroad shall be stacked not less than ten (10) ft. from the nearest rail of any track at suitable and convenient places; but not at public crossings, nor where they will interfere with the views of trainmen or of people approaching the railroad. Ties should be stacked in alternate layers of two (2) and seven (7), the bottom layer to consist of two ties kept at least six inches above the ground. The second layer shall consist of seven ties laid crosswise of the first layer. When the ties are rectangular, the two outside ties of the layers of seven and the layers of two shall be laid on edge. The ties in layers of two shall be laid at the extreme ends of the ties in the layers of seven. No stack may be more than twelve layers high, and there shall be five feet between stacks to facilitate inspection. Ties may be ranked like cordwood, in which case the owner shall rehandle them while inspection is being made. Ties which have stood on their ends on the ground will be rejected.

All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

Ties shall be piled as grouped below. Only the kinds of wood named in the same column may be piled together.

Class U—Ties Which May Be Used Untreated

GROUP Ua	GROUP Uc
Black Locust	"Heart" Cedars
White Oaks	"Heart" Cypress
Black Walnut	Redwood
	GROUP Ud
	Catalpa
GROUP Ub	Chestnut
"Heart" Pines	Red Mulberry
"Heart" Douglas Fir	Sassafras

Class T—Ties Which May Be Used Treated

GROUP Ta	GROUP Tc
Ashes	Beech
Hickories	Birches
Honey Locust	Cherry
Red Oaks	Gums
	Hard Maples

GROUP Tb	GROUP Td
"Sap" Cedars	Elms
"Sap" Cypress	Hackberry
"Sap" Douglas Fir	Soft Maples
Hemlocks	Spruces
Larches	Sycamore
"Sap" Pines	White Walnut

Shipment. Ties shall be separated in the car according to the above groups and sizes as far as practicable.

TIE, CULL. A tie which does not conform to the specifications. (A. R. E. A.)

Ties are subjected to rejection on account of decay and various other defects, such as being too narrow in face or thickness or too short. Sometimes hewed ties are crooked and sawed ties are cross-grained or the opposite faces are not parallel; or the ties may be too wide. The timber may be wind-shaken, or contain loose or decayed knots, or show fungus growth or worm holes, or it may be from a burnt or dead tree. Culls are painted with distinguishing marks and left on the ground at the owner's risk, the contract usually stipulating a time within which the producer must remove them from railway property.

TIE, DOTY. A tie affected with a fungus disease. (A. R. E. A.)

The first signs of infection are usually on the surface although many ties start to decay from the inside or the spores may not develop until after the tie is manufactured or treated. If the infection is internal the tie may continue to decay in spite of the preservative treatment until the sound outer shell of treated wood breaks down. Winter felling of timber tends to minimize this danger as, during this season the low temperature discourages decay and spores are not plentiful.

TIE, HALF-ROUND. A slabbed tie having greater width on the lower than on the upper face. (A. R. E. A.)

Some logs will yield two ties of this kind with the narrower faces six inches or more in width. If their least area of cross section is not less than that specified for sawed ties of the same class they are usually acceptable. A half-round tie is commonly laid with the narrow face uppermost in a secondary track where a broad bearing in fine ballast is desirable.

TIE, HEART. A tie showing, on one or two corners only, sapwood which does not measure more than one inch on either corner, along lines drawn diagonally across the end of the tie (A. R. E. A.), which, if for use without preservative treatment, is valued according to its percentage of the finer grained and tougher heart wood.

TIE, HEWED. A tie made by hand with an axe, as distinguished from those which are machine sawed. Ties are commonly hewed from small trees of such diameter that flatting the log on two opposite faces is sufficient. They are sometimes hewed from larger timber which is first split to the proper size. Hewed ties usually have sapwood on one or more sides and the faces are not always plane surfaces as in sawed ties, which are favored especially because of their regularity in dimensions.

TIE, INTERMEDIATE. Any cross tie used between joint ties. (A. R. E. A.)

In broken joint track there are 14 to 16 intermediate ties per 33 ft. panel. While it is usual to select ties with a view to obtaining the best bearing under the rail joints, the intermediate ties should be selected and spaced with a view to general uniformity of rail bearing.

TIE, JOINT. A tie used as a support for a rail joint. The usual arrangement is to place two ties under the joint, which is then termed a suspended joint. When three ties are used the middle tie is placed directly under the rail ends and the joint is termed a supported joint. Joint ties are usually selected with special care, particularly when used for opposite joint track, for in that case both ends of the ties are subjected to the heavy load from the joints. It is the practice even in laying broken joint track to select joint ties with a view to obtaining the best rail bearing pieces to carry the extra load applied there.

TIE, PECKY. A tie made from a cypress tree affected by a fungus disease, known locally as peck. (A. R. E. A.)

Pecky cypress is acceptable unless the holes in the wood are so numerous or extensive as to seriously affect its strength.

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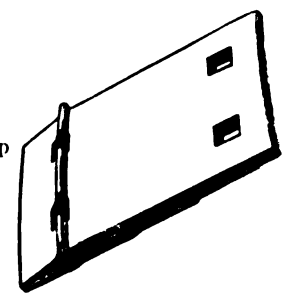
TIE PLATE. A bearing piece, usually of metal, designed to be inserted between the base of a rail and the top of a tie to minimize the wear due to friction between the track members and to improve the distribution of the loads.

It is commonly of rectangular shape, 6 in. to 7 in. wide, but preferably as wide as the top face of the tie will permit, and long enough to afford the desired bearing area on the tie with safe margins of metal between its edges and the holes punched for the track spikes, while its thickness is such as will prevent failure in service. Types in general use are from ⅜ in. to ½ in. thick, 6 in. to 7 in. wide and 8 in. to 11 in. long, the dimensions being varied with the widths of the rail bases and the ties, the weights of the wheel loads and the classes of timber used as ties. The present tendency is to increase the thickness and the surface area with a view to greater strength and distribution of the load.

The bottom surface of a tie plate may be rolled flat or with corrugations, projections, ridges or parallel ribs to prevent the device from sliding from its seat on the tie. Some types have pin or chisel-pointed spikes at the corners, while others are provided with from two to five sharp-edged parallel ribs from ½ in. to 1 in. deep, extending the entire length of the plate. Others have crossed corrugations or variously placed ridges from ⅛ in. to $\frac{3}{16}$ in. deep, designed to indent the tie sufficiently to seat the plate and at the same time avoid possibility of injury to the wood fibre. The A. R. E. A. recommends flat bottomed tie plates or designs having few ribs or corrugations not over ¼ in. deep, for use on treated ties or with screw spikes.

The top face of the tie plate is sometimes a plane surface, but is usually beveled from full thickness at the lines of the rail bearing to about one-half thickness at the ends of the plate, and rolled with a shoulder or a pair of lugs which form a side bearing for the outside edge of the rail flange for the purpose of holding the rail to gage. Sometimes tie plates are made with two parallel shoulders spaced so that the base of the rail fits between them. Some of these double shoulder designs have one hooked shoulder which overlaps the edge of the rail base. The vertical faced shoulder which is in more general use is designed to be low enough to permit the spike head, when seated, to come down into firm contact with the rail flange, but high enough to

Top and Bottom Views of Wolhaupter Shoulder Corrugated and Cambered Top and Ribbed Bottom Tie Plate
The Railroad Supply Co.
(See Page 779)

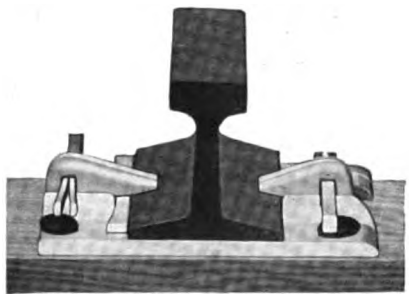


Lundie Tie Plate
The Lundie Engineering Corporation
(See Page 736)

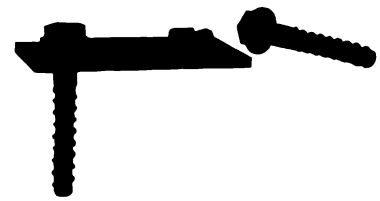
Hook Shoulder Tie Plate
The Railroad Supply Co.
(See Page 779)

Wolhaupter Canted Top Tie Plate
The Railroad Supply Co.
(See Page 779)

Clary Tie Plate
The Cleveland Railway Supply Co.



McSafety Tie Plate
The Railway Safety Tie Co.
(See Page 783)



Newhall Screw Spike Tie Plate
The Cleveland Railway Supply Co.

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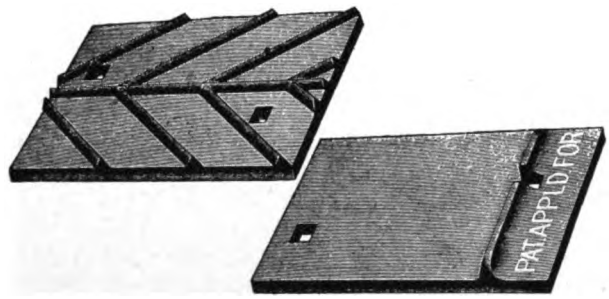
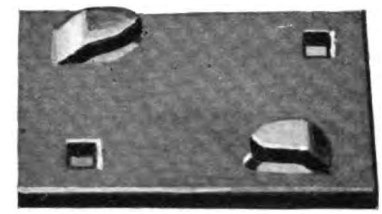
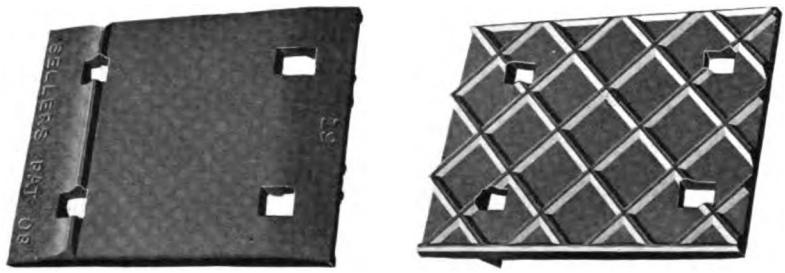


Top and Bottom Views of Cross Rolled Iron Tie Plate with Herringbone Bottom
The Interstate Iron and Steel Co.
(See Page 720)



Pressed Steel Tie Plate
The Elliott Frog & Switch Co.

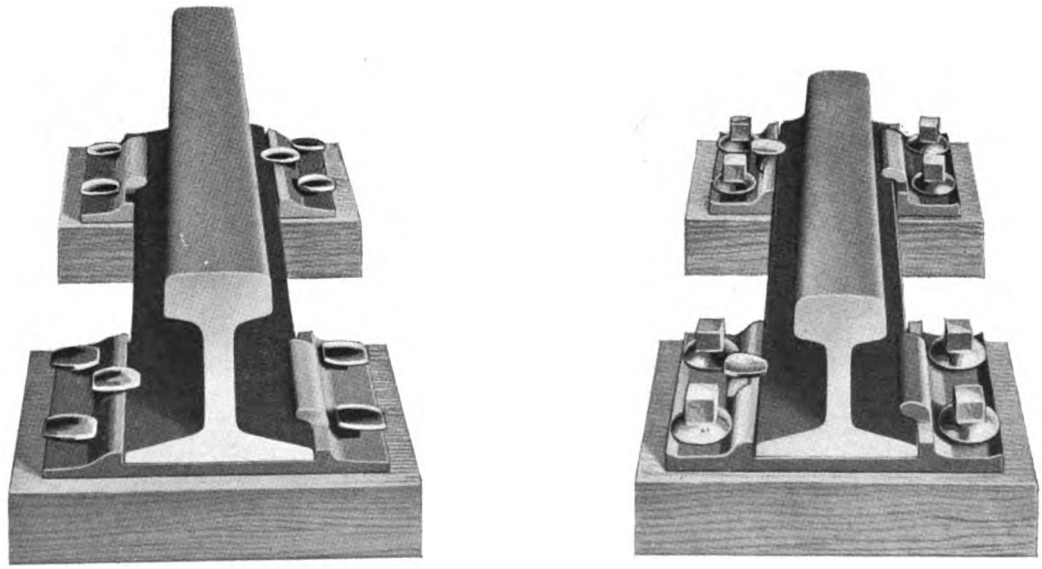


Top and Bottom Views of the Sellers Anchor Bottom Tie Plate
The Sellers Manufacturing Co.
(See Page 802)

Dilworth Cushion Tie Plate
Dilworth, Porter and Co., Inc.

Top and Bottom Views of the Atlas Screw Spike, Ribbed Bottom Tie Plate
The Atlas Railway Supply Co.

Goldie Claw Tie Plate
Dilworth, Porter and Co., Inc.



Hook Shoulder Tie Plates for Cut and Screw Spikes
The Lackawanna Steel Co.

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overcome the tendency of the shoulder to slip under the base of the rail, owing to wave motion. According to the recommendations of the A. R. E. A., the minimum height of shoulder is one-half inch. The lugs sometimes cast on the upper surface of the tie plate in lieu of shoulders are stops similar in form to miniature rail braces, presenting oval or semi-circular vertical bearing faces in line with the edge of the rail base.

Spike holes are variously spaced in shoulder tie plates to fit the base of the rail and the tie and to preserve the strength of the plate, but at least one hole is provided for a rail spike on the outside and one on the inside of the track about one inch from the opposite sides of the plate, while plates without shoulders commonly have four or more spike holes. Shoulder tie plates are generally punched with at least three rail spike holes and sometimes two or more plate spike holes, the latter holding the plate only to the tie. Rail spike holes are frequently so placed that the tie plate will fit rail bases of two or more widths. In order to transmit the outward thrust of the rail flange to the spike at the surface of the tie the holes are made only large enough to receive the spike with little or no play. Tie plates designed for use with screw spikes are usually supplied with a lug or shoulder having a flat segmental top surface support for the head and a round hole for the shank of each screw spike, while in some designs square holes are also provided for cut spikes which hold the tie plate only to the tie.

To further take care of the outward thrust the tie plate is usually made longer outside than inside the rail base so that about 52 per cent of the area of the tie plate is outside the vertical axis of the rail. Some styles of tie plate are tapered in thickness from the outside to the inside end, with a view to canting the rail inward. Some types are cambered, while some are made in combination with rail braces or anti-creeper features or both. The present tendency is toward designs which best protect the members of the track structure and help to secure them in their proper relative positions. Tie plates for ties supporting rail joints are made of extra length to fit the bases of the assembled joints, and are punched with spike holes to correspond with the spike slots in the joint bars.

Tie plates are commonly made of wrought iron, malleable iron or steel, the selection of any one of these metals being based largely on local traffic conditions. The metal should be corrosion-resisting when installed in tracks subject to brine dripping from passing refrigerator cars. It should be of ample hardness to withstand the severe shocks of the traffic imposed, tough enough to prevent failure and thick enough to allow for increasing wheel loads which tend to bend the ends up or to break the plate at the outside edge of the rail base.

The effects of brine dripping from refrigerator cars or of sea water is to corrode the metal in spots, the surface showing pits which gradually deepen and multiply until the entire plate becomes irregularly thinner than the original section, wearing sharp at the edges and finally bending up or breaking along the lines of the rail base, usually at the outside first.

An intermediate tie is furnished with one right hand and one left hand tie plate, punched with spike holes staggered to correspond with the approved method of spiking, while joint ties are supplied with special tie plates punched to correspond with the slotting of the joint bars and long enough to accommodate the assembled joint.

A board with a cleat nailed at right angles across one end is frequently used as a gage for the location of the plates on the ties in laying new track. Sometimes a wooden maul is used to settle the bottom surface of the plate into the top of the tie, but the practice is not general, for after laying is completed and the track is in operation, the pressure of the wheel loads of the first few trains is sufficient to seat the tie plates, which settle on the ties, after which a final tightening of the spikes is necessary.

The service life of a tie plate depends largely on its bearing on the tie, which should be a true plane surface, ties being usually machine adzed or carefully hand adzed for that purpose. The latter method is especially necessary when replacing tie plates on ties renewed in track under traffic, when relaying track with heavier section rail and when preparing seats for plates on rail-cut ties. Tie plates fail usually by turning up at the edges outside the rail bearing, on account of improper seating or deterioration of the metal.

Shipment is ordinarily made of rights, lefts and joint tie plates in separate bundles of ten, tied with wire through the spike holes and usually marked "R," "L" or "J" with white paint, to facilitate distribution.

The following specifications have been adopted by the A. R. E. A. for tie plates made of wrought iron, malleable iron and steel:

Specifications for Wrought-Iron Tie Plates

I. Material

1. Plates shall be made of all-pig puddled iron.

II. Physical Requirements

2. The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in..48,000
Yield point, lb. per sq. in.....0.6 tensile strength
Elongation in 2-in., per cent....28
Elongation in 8-in., per cent....25
Reduction of area, per cent....37

3. **Bend Tests.** The bend test specimen shall bend cold through 180 deg. without fracture around a pin the diameter of which is equal to the thickness of the specimen.

4. **Test Specimens.** (a) The tension test specimens shall be taken from the finished tie plates, or from the rolled bar. They shall be cut so that the sides of the specimens are parallel to the direction in which the tie plates have been rolled.

(b) Tension test specimens may conform to the essential dimensions shown in Fig. 1 or Fig. 2. The 2-in. specimen (Fig. 1) shall have filleted shoulders, or threaded ends, to fit into the holders on the testing machine in such a way that the line of action of the force exerted by the testing machine shall coincide with the axis of the specimen.

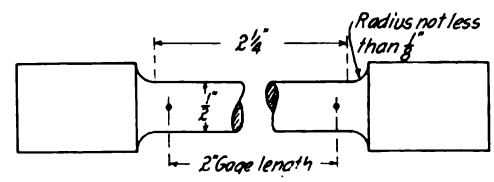

Figure 1

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NOTE:—The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any form which will fit the Holders of the Testing Machine.

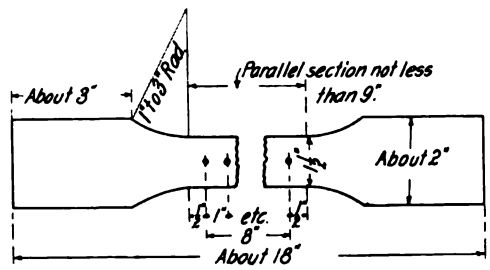

Figure 2

5. **Number of Tests.** (a) One tension test and one bend test shall be made from each lot of 100 tie plates.

(b) If any test specimen from either of the bars originally selected to represent a lot of material contains surface defects not visible before testing, but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, the individual bar shall be rejected and one retest from a different bar will be allowed.

III. Design

6. **Plan.** The tie plates shall conform to the drawings submitted to the manufacturer, with the following permissible variations:

(a) **Variations.** For plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{1}{8}$ in. in rolled width, and $\frac{3}{16}$ in. in sheared length will be permitted.

(b) For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{1}{8}$ in. in rolled width, and $\frac{1}{4}$ in. in sheared length will be permitted. The distance from the face of the shoulder to the outside end of plate shall not vary more than $\frac{1}{4}$ in., and from the face of shoulder to the inside end not more than $\frac{1}{2}$ in.

IV. Manufacture

7. **Workmanship.** The tie plate shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearings for the rail and have a workmanlike finish.

8. **Finish.** The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching; they shall also be free from slivers, depressions, seams, crop ends and evidences of being burnt.

9. **Marking.** The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

V. Inspection

10. **Inspection.** The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

11. **Rejection.** If either of the test bars selected to represent a lot does not conform to the requirements specified in Sections 2, 3, 4 and 5, the lot will be rejected.

VI. Shipment

12. **Packing.** Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb. for shipment, unless otherwise specified.

SPECIFICATIONS FOR MALLEABLE IRON TIE PLATES

I. Material

1. Plates shall be made from furnace malleable iron.

II. Physical Requirements

2. **Tension Tests.** The tension test specimens specified in Section 4 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.....45,000
Elongation in 2 in., per cent..... 7.5

3. **Special Tests.** (a) All tie plates shall have cast thereon test lugs of a size proportional to the thickness of the tie plate, but not exceeding $\frac{5}{8}$ by $\frac{1}{4}$ in. in cross-section. These lugs shall be attached to the tie plate at such a point that they will not interfere with the assembly of the tie plates, and may be broken off by the inspector.

(b) If the purchaser or his representative so desire, a tie plate may be tested to destruction. Such a tie plate shall show good, tough, malleable iron.

4. **Tension Test Specimens.** (a) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Specimens whose mean diameter at the smallest section is less than $\frac{1}{2}$ in. will not be accepted for test.

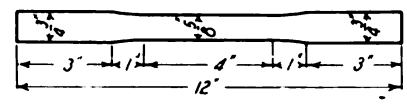

Figure 1

(b) A set of three tension test specimens shall be cast from each melt, without chills, using risers of sufficient height to secure sound bars. The specimens shall be suitably marked for identification with the melt. Each set of specimens so cast shall be placed in some one oven containing tie plates to be annealed.

5. **Number of Tests.** (a) After annealing, three tension test specimens shall be selected by the inspector as representing the tie plates in the oven from which these specimens are taken.

(b) If the first specimen conforms to the specified requirements, or if, in the event of failure of the first specimen, the second and third specimens conform to the requirements, the tie plates in that oven shall be accepted, except that any tie plate may be rejected if its test lug shows that it has not been properly annealed. If either the second or third specimen fails to conform to the requirements, the entire contents of that oven shall be rejected.

6. **Re-annealing.** Any tie plates rejected for insufficient annealing may be re-annealed once. The re-annealed tie plates shall be inspected and if the remaining test lugs, or tie plates broken as specimens, show the tie plates to be thoroughly annealed, they shall be accepted; if not they shall be finally rejected.

III. Design

7. **Plan.** Tie plates shall conform to the drawing submitted to the manufacturer, with the following permissible variations:

(a) The length and width shall not vary more than $\frac{1}{8}$ in. from the dimensions shown.

(b) The thickness shall not vary more than $\frac{1}{32}$ in. from the dimensions shown.

IV. Manufacture

8. **Workmanship.** The plates shall be straight and out of wind on the surface which forms the bearings for the rail, and shall be made in a workmanlike manner.

9. **Finish.** The finished tie plate shall be well cleaned and free from warping, shrinkage, cracks, blowholes, fins, and other imperfections.

10. **Marking.** The manufacturer's identification mark and the pattern numbers assigned by the purchaser shall be cast on all tie plates in such positions that they will not interfere with the service of the tie plate.

V. Inspection

11. **Inspection.** (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reason-

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able facilities to satisfy him that the tie plates are being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(b) The manufacturer shall be required to keep a record of each melt from which tie plates are produced, showing tensile strength and elongation of test specimens cast from such melts. These records shall be available and shown to the inspector whenever required.

12. **Rejection.** Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works may be rejected, and, if rejected, shall be replaced by the manufacturer free of cost to the purchaser.

VI. Shipment

13. **Packing.** Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb., for shipment, unless otherwise specified.

Specification for Steel Tie Plates

1. These specifications cover two grades of steel tie plates, namely, soft and medium. The soft grade steel shall be used unless otherwise specified.

I. Material

2. **Process.** Steel may be made by the Bessemer or open-hearth process.

II. Chemical Requirements

3. **Phosphorus.** (a) The steel shall conform to the following requirements as to chemical composition:

Phosphorus.....	Bessemer—Not over 0.10 per cent. Open-hearth—Not over 0.05 per cent.

(b) **Carbon.** Unless otherwise specified, the material will be furnished according to chemical composition only, in which case the minimum carbon shall be as follows:

Bessemer Carbon	Soft Grade Not under 0.08 %.	Medium Grade Not under 0.12 %.
Open-Hearth Carbon	Soft Grade Not under 0.15 %.	Medium Grade Not under 0.20 %.

4. **Ladle Analysis.** (a) A carbon determination shall be made of each melt of Bessemer steel, and two analyses every 24 hours representing the average of the elements, carbon, manganese, phosphorus and sulphur contained in the steel, one for each day and night turn respectively. These analyses shall be made from drillings taken at least ⅛ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

(b) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from drillings taken at least ⅛ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition, thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. **Check Analysis.** An analysis may be made by the purchaser from a finished tie plate representing each melt of open-hearth steel, and each melt or lot of 10 tons of Bessemer steel. The carbon content thus determined shall not be less than that specified in Section 3, and the phosphorus content shall not exceed that specified in Section 3 by more than 25 per cent.

III. Physical Requirements

6. **Bend Test.** The bend test specimens specified in Section 7 shall bend cold through 180 deg. around a pin the diameter of which is equal to the thickness of the specimen for the soft grade, and to twice the thickness of the specimen for the medium grade, without cracking on the outside of the bent portion.

7. **Test Specimens.** Bend test specimens shall be taken from the finished tie plates, or from the rolled bars, and longitudinally with the rolling. They shall be rectangular in section, not less than ½ in. in width between the planed sides, and shall have two parallel faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, these ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

8. **Optional Bend Test.** If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 6:

A piece of the rolled bar shall bend cold through 90 deg. around a pin the diameter of which is equal to the thickness of the section, where bent for the soft grade, and to twice the thickness of the section where bent for the medium grade, without cracking on the outside of the bent portion.

9. **Number of Tests.** (a) One bend test shall be made from each melt of open-hearth steel, or from each melt or lot of 10 tons of Bessemer steel.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

10. **Tension Tests.** (a) If desired by the purchaser or for the reason that the manufacturer does not make his own steel bars and is not able to make the chemical analysis of the steel, the material may be purchased to conform to the following minimum requirements as to tensile properties:

	Soft Grade	Medium Grade
Tensile Str., lb. per sq. in...	55,000	64,000
Yield point, lb., per sq. in....	0.5 tens. str.	0.5 tens. str.
Elongation in 2-in., per cent..	1,500,000	1,500,000
	Tensile Str.	Tensile Str.
But in no case less than.....	20 per cent.	18 per cent.
Elongation in 8-in., per cent..	1,400,000	1,400,000
	Tensile Str.	Tensile Str.
But in no case less than.....	18 per cent.	16 per cent.
Reduction of area, per cent..	30 per cent.	25 per cent.

Test Specimens. (b). The tension test specimens shall be taken from the finished tie plates, or from the rolled bar. They shall be cut so that the sides of the specimens are parallel to the direction in which the tie plates have been rolled.

(c) Tension test specimens may conform to the essential dimensions shown in Fig. 1 or Fig. 2. The 2-in. specimen (Fig. 1) shall have filleted shoulders, or threaded ones, to fit into the holders on the testing machine in such a way that the line of action of the force exerted by the testing machine shall coincide with the axis of the specimen.

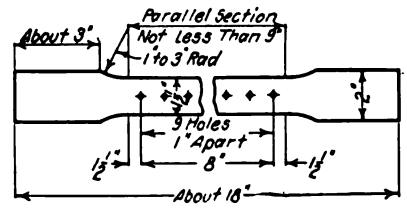

Figure 1

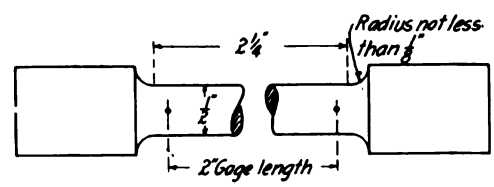

Figure 2

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Note.—The gage length, parallel portions and fillets shall be as shown, but the ends may be of any form which will fit the holders of the testing machine.

(d) Or, tension test specimens may be rectangular in section, in which case they shall be not less than ½ in. in width between the planed sides, and shall have two parallel faces as rolled. When the tie plates are of such a design that the rectangular specimens cannot be obtained without projecting ribs, these shall be planed off before the tests are made.

11. **Number of Tests.** (a) One tension test shall be made from each melt of open-hearth steel, and from each melt or lot of 10 tons of Bessemer steel.

(b) If any test specimen shows defective machining, or develops flaws, or if it breaks outside the gage length, it may be discarded and another specimen substituted.

12. **Retests.** If the percentage of elongation of any tension test specimen is less than that specified in Section 5, or if any part of the fracture is more than ¾ in. from the center of the gage length of a 2-in. specimen, or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. Design

13. **Plan.** The tie plates shall conform to the drawings submitted to the manufacturer, with the following permissible variations:

Tolerance. (a) For plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, ⅛ in. in rolled width, and $\frac{1}{16}$ in. in sheared length will be permitted.

(b) For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, ⅛ in. in rolled width, and ¼ in. in sheared length will be permitted. The distance from the face of shoulder to the outside end of the plate shall not vary more than ¼ in., and from the face of shoulder to the inside end not more than ½ in.

V. Manufacture

14. **Workmanship.** The tie plate shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearings for the rail.

15. **Finish.** The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching; they shall also be free from other injurious defects and shall have a workmanlike finish.

16. **Marking.** The name or brand of the manufacturer shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

VI. Inspection

17. **Inspection.** The inspector representing the purchaser shall have free entry, at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

18. **Rejection.** (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

19. **Rehearing.** Samples tested in accordance with Section 5, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

VII. Shipment

20. **Packing.** Tie plates shall be wired together in bundles of uniform number, weighing not to exceed 100 lb., unless otherwise specified.

TIE PLATE, CAMBERED. A tie plate slightly bent to make its rail bearing convex lengthwise of the rail so that the whole width of the rail base rests on the high center of the tie plate but does not quite touch the depressed side edges. The object in cambering a tie plate is to utilize the flexure to ease the shock of wheel loads, as well as to obviate the tendency of the plate to tilt under traffic and the consequent rocking of ties due to the sudden pressure of the rail base on the receiving edge of the tie plate.

TIE PLATE, CANTED. A tie plate tapered in thickness, usually ⅛ in., for the purpose of canting the rail toward the center of the track to compensate for the standard coning of car wheels and give a fuller and more central bearing on the rail.

TIE PLATE, COMBINATION. A tie plate made as a portion of a device designed to perform the functions of a tie plate and one or more other devices, such as an anti-creeper tie plate, a rail brace tie plate, etc. An advantage of the combination is that it tends to simplify the device and minimize the number of parts, which is generally desirable in track devices, provided no part of this efficiency or adaptability of either is thereby sacrificed. See Rail Brace. Also Anti-Creeper. Also Guard Rail Brace.

TIE PLATE, DOUBLE SHOULDER. A tie plate with two parallel shoulders between which the rail base fits. An advantage of such a tie plate is that the shoulders tend to bind the base of the rail between them and counteract the tendency to creep. On the other hand, this style of tie plate is limited to one width of rail base, whereas a single shoulder plate need only be repunched for spikes at the proper distance from the shoulder to accommodate any width of rail base. Double shoulder tie plates are rolled and used to a limited extent.

TIE PLATE, GUARD RAIL. A special tie plate of sufficient length to support the bases of the guard rail and the adjacent running rail. This plate is commonly used with frog guard rails, being punched for track spikes in such a way to allow for flangeway adjustments and frequently designed in combination with a rail brace. It is also sometimes used under curve or bridge guard rails.

TIE PLATE, HOOK SHOULDER. A double shoulder tie plate with one straight shoulder, and one high inwardly-bent shoulder designed to hold the rail flange down on the plate as well as to gage, thus performing the functions of the track spike. The plates are usually spiked independently to the tie with all the hook shoulders on the gage side of the rail, which may be removed by drawing the track spikes from the outside and tilting the base.

TIE PLATE, INTERMEDIATE. A tie plate designed to be placed on any cross tie laid between the joint ties which support the ends of a rail. Intermediate tie plates are usually shorter than joint tie plates, because the width of the rail base is less than the width of an applied rail joint, which involves members extending beyond the edges of the bases of the rails.

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TIE PLATE, JOINT. A special tie plate made of suitable length to support the base of the rail joint and sometimes punched for slot spikes. See Rail Joint.

TIE PLATE, LUG. A tie plate designed with top projections called lugs instead of ridge shoulders. The lugs are placed on each side of the track spike holes and in line with the edge of the rail flange to act as stops to hold the rail to gage.

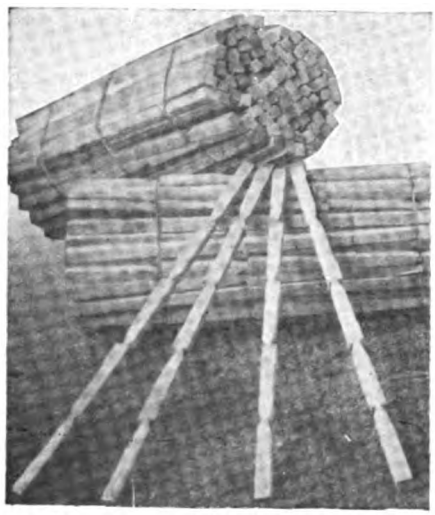
TIE PLATE, PLAIN TOP. A tie plate without shoulders, usually punched for two or more track spikes to hold the plate and the rail in place on the tie.

TIE PLATE, SCREW SPIKE. A tie plate punched with round holes and usually made with flat topped lugs to provide bearing surfaces for the heads of screw spikes.

TIE PLATE, SHOULDER. A tie plate with a ridge of metal extending across its top surface parallel with the ends of the plate in such a position that the edge of the rail base will bear against it. The shoulder is made strong enough and high enough to act as a stop to spreading rails, the minimum height being ½ in. In section the shoulder commonly has a vertical face for the rail bearing, a broad base and a sloping or curved back, and is usually cut through with two spike holes. An advantage of the shoulder tie plate is that of definitely limiting the position of the rail which cannot crowd and cut the spike or widen the gage. It also insures a margin of tie plate metal outside the edge of the base of the rail to counteract the tendency to overturn. Present American practice favors the single shoulder tie plate.

TIE PLUG. A wooden dowel designed to be driven into and to fill a disused spike hole in a track tie with a view to excluding moisture, preventing decay and providing a bearing for redriving the spike. This device is commonly a hard wood, machine-made, chisel-pointed, square or round, flare-headed pin of about the dimensions of the track spike, preferably treated with a wood preservative, and usually shipped in sacks of 1000 pieces.

Goldie Tie Plug
Wm. Goldie, Jr., and Co.



Tie Plugs in Stick Form
The Arkansas Hickory Co.

TIE, POLE. A tie hewed or sawed on two parallel faces from a tree of such size that not more than one tie can be made from a section. Pole ties are commonly hewed from young live timber and are generally desirable, but the faces are not perfectly plane surfaces as in sawed ties. The area of the least cross section of a hewed tie must equal the sectional area of a sawed tie of that class.

TIE, SAP. A tie which shows more than the prescribed amount of sap-wood in cross section. (A. R. E. A.)

Ties made from needle leaved trees for use without preservative treatment and having more than 2 in. of sap-wood on the top of the tie, are designated as sap ties.

TIE, SAWED. A wooden tie which is machined on all surfaces. It is frequently made of a boxed heart; that is, lumber is sawed from all four sides of the log until only a central squared stick of heart wood remains, and this is used as a tie. The increasing cost of labor for hewing as well as the growing scarcity of tie timber has led producers to increase the manufacture of sawed ties. Almost all switch ties are sawed, because the plane surfaces of the sawed tie are more suitable for the seating of switches, frogs and crossings.

TIE SPACER. A device used for straightening and spacing ties in track with a minimum disturbance of the ballast, commonly a one-piece steel rail clamp about 16 in. long, rectangular in section with one end extended as a lever arm and used as a fulcrum for a lever by means of which the tie is moved. This device is sometimes designed to fit over the

Blair Tie Spacer
The Maintenance Equipment Co.

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head of the rail and sometimes to clasp beneath the base of the rail. Both types are intended to be placed close to the tie with the lever arm on the outside of the rail so that a track bar held upright can be placed in a groove provided on the side of the lever arm and brought to bear against the tie below, before applying leverage in a vertical plane parallel to the rail. The parallel sides of the clamp grip the sides of the base or head of the rail, holding the spacer firmly in place, while the tie is forced to the desired position by the pressure of the track bar against the tie. A track jack is sometimes used as a spreader in place of a bar, the foot of the jack being placed against the tie and the head against the spacer, while the handle is operated in a vertical arc parallel with the rails.

TIE SPACING. The distances or spaces between the centers of adjacent ties of a switch set in place, measured along the center line of the track.

TIE, STEEL. A tie the essential parts of which

Carnegie Steel Cross Tie
The Carnegie Steel Co.

are composed of steel.

TIE, STRICT HEART. A tie having no sapwood. See Tie, Heart.

TIE, SUBSTITUTE. Any tie other than a wood tie. (A. R. E. A.)

As a tie material, steel has received more consideration than any other substitute for wood. Reinforced concrete combined with steel and either or both materials combined with wood blocks, have been used for this purpose, with the object of producing a support for the rails possessing strength, resiliency, rail bearing area and insulating qualities comparable with the wooden tie. These designs are still in the experimental stage, except possibly the steel ties, certain designs of which are largely used on some foreign lines and on one or two American railways.

TIE, SWITCH. A timber of a set used as cross ties to support a turnout from the point of the switch to the heel of the frog. A switch tie is long enough to support the rails of the parent and turnout tracks, extending about 18 in. beyond the outside rails. They vary usually in length from 8 ft. 6 in. near the switch points to 16 ft. at the heel of the frog, their lengths increasing in increments of from 3 in. to 12 in. to conform to the divergence of the outside rails of the diverging tracks. They are usually sawed to specified dimensions, delivered in sets, marked as to length and bought by board measure under cross tie specifications except as to length. A set of switch ties preferably includes two ties 12 ft. to 16 ft. long to bear the switch points and switch stand, although one timber is sometimes used. These timbers are called head blocks, head block ties, or switch stand ties. Switch ties are usually sawed on all sides and are 7 in. by 9 in. or more in section.

Practice in renewing them varies from replacing them in sets or half sets, or renewing singly up to half sets to renewing single ties. The renewal of single switch ties causes such disturbance of the ballast that rough track usually results, while in ladder tracks the renewal of a single tie may delay all traffic over the ladder. A common practice is to renew the ties of main line switches in sets and to reuse the serviceable second-hand ties or sections of ties in secondary tracks.

On some lines, single switch ties of a set are renewed unless half the set must be replaced, in which case a full new set is installed and the good ties removed are re-used singly or otherwise in yard or industrial tracks.

TIE TAMPER. See Ballast Tamper.

TIE TONGS. An implement, similar to ice tongs, but used for carrying ties, etc. It commonly consists of a pair of ¾-in. steel bars so shaped as to form circular jaws with spike-like nippers on their lower extremities and fastened together with a central rivet. The shoulders, which terminate in short shanks, are bent oppositely at right angles to form handles about 15 in. long. This tool operates scissors-fashion, the spike-like nippers hooking firmly into the wood of the tie as the handles are raised. The tie is carried between two men, each one holding a handle.

TIE, TREATED. A tie which has been subjected to a preservative process designed to protect it from decay. (A. R. E. A.)

The usual mode of treatment is to subject the tie to impregnation by a solution of creosote or zinc chloride or both under pressure. Ties are selected, adzed, piled and thoroughly air-dried before treatment, this seasoning process usually occupying from four months to a year. If they are to be used with screw spikes they are also bored prior to treating. The usual treatment injects about 10 lb. of creosote or ½ lb. of dry zinc chloride per cu. ft. of wood.

TIE, WANE. A squared tie showing part of the original surface of the tree on one or more corners (A. R. E. A), this natural curvature creating a deficiency in the rectangular section of the piece.

TOE (Frog). The end of a turnout frog nearest the switch point.

TOE EXTENSION. The extension of the manganese casting in a manganese steel frog which fills the space and acts as a splice between the toe connecting rails. A solid manganese frog may have two toe extensions outside of the toe connecting rails, which act as easer splices. In this case they are termed right hand toe extension if on one's right hand side when facing the end of the frog point, the left hand toe extension being on the opposite side.

TOE LENGTH (Frog.) The distance from the actual point to the toe of the frog measured along the gage line.

TOE SPREAD (Frog). The spread between the gage lines at the ends of wing rails at the toe of frog.

TOE STAGGER. The difference in length when the toe length of the rigid wing rail of a spring rail frog is made differently from the toe length of the spring wing. To admit using curved and straight

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closure rails of the same length the rigid rail is frequently made about 2 in. longer than the spring wing rail.

TOOL, ROADWAY. A tool used by trackmen in maintaining the track or other railway property on the right-of-way.

The term is commonly applied to the tools and equipment issued to section gangs, the quantities varying with the number of laborers in the gang and the class of the service. The following list is fairly typical of the tools issued by several western railway systems for the use of maintenance of way gangs:

KIND OF TOOL	FOREMAN AND 2 Men	4 Men	6 Men	8 Men	10 Men
Adzes with handles	1	1	2	2	2
Axes with handles	1	1	1	1	1
Bars, Claw	2	2	3	3	4
Bars, Lining	3	5	6	7	8
Bars, Tamping	2	4	6	7	8
Brooms	3	3	4	4	5
Cans, Oiler	1	1	1	1	1
Cans, One gallon oil	1	1	1	1	1
Cans, Five gallon oil	1	1	1	1	1
Cars, Hand	1	1	1	1	1
Cars, Push	1	1	1	1	1
Cars, Motor (where assigned)	1	1	1	1	1
Chains, Car	2	2	2	2	2
Chisels, Track	6	6	6	6	6
Cups, Tin	2	2	2	2	2
Drills	1	1	1	1	1
Drill Bits (of each size required)	3	3	3	3	3
Files	1	1	1	1	1
Funnels	1	1	1	1	1
Fuses, Red	4	4	4	4	4
Gage, Track	1	1	1	1	1
Grindstones, complete	1	1	1	1	1
Handles, extra for Adzes	1	1	2	2	2
Handles, extra for Axes	1	1	1	1	1
Handles, extra for Mauls	2	3	3	4	4
Handles, extra for Picks	1	1	2	2	2
Handles, extra for Jacks	1	1	1	2	2
Hoes, Scuffle	3	5	7	8	10
Jacks, Track	1	1	1	2	2
Kegs, Water, 5 gal.	1	1	..	..	..
Kegs, Water, 10 gal.	..	..	1	1	1
Lanterns, complete white	2	2	2	2	2
Lanterns, complete red	2	2	2	2	2
Lanterns, complete yellow	2	2	2	2	2
Lantern Globes, extra, yellow	1	1	1	1	1
Lantern Globes, extra, red	1	1	1	1	1
Lantern Globes, extra, white	1	1	1	1	1
Levels, Track	1	1	1	1	1
Lines, Tape 50 feet	1	1	1	1	1
Lines, Rope 100 feet	1	1	1	1	1
Mauls, Spike	3	4	4	5	5
Picks, Clay	2	3	3	4	4
Punch, Track, with handle	1	1	1	1	1
Rakes	1	1	1	1	1
Saws, Hand	1	1	1	1	1
Scythes, with Snathes	3	5	7	8	8
Shovels, Track, No. 2	4	6	8	10	12
Shovels, Snow, No. 2	2	3	4	5	6
Sledges	1	1	1	1	1
Signal Flags, red	3	3	3	3	3
Signal Flags, yellow	2	2	2	2	2
Tongs, Tie	1	2	2	3	3
Tongs, Rail	2	2	3	4	4
Torpedoes	12	12	12	12	12
Wrenches, Monkey	1	1	1	1	1
Wrenches, Track, two sizes	4	6	6	6	6
Wrenches, Frog	1	1	1	1	1

Each roadmaster shall keep on hand as necessary, at one central point, such tools as:

1 Roller Rail Bender.
1 Rail Bender, ordinary
2 Track Drills.
6 Drill Bits for each size of rail.
2 Rail Forks.
12 Scoop Shovels.
12 Snow Shovels.
1 Cross Cut Saw.
2 Track Jacks.
4 Rail Tongs.
3 Post Hole Diggers.
2 Wire Stretchers.
4 Wire Pliers.
6 Wheelbarrows.

TOP PLANING (Switch). The cut made on the top of the head of switch point rail from the point end to the point of separation of heads.

TRACK. A pair of parallel lines of rails secured with fastenings on cross ties for the purpose of carrying rolling stock on flanged wheels, the fastenings commonly including joint bars and base plates, track bolts and nuts, nut locks, lock nuts or lock washers, tie plates, spikes and anti-creepers.

Railway track is laid on a prepared roadway of earth, etc., with ample slopes of sufficient top width to stabilize the structure and form a base for the ballast on which the track rests and in which the cross ties are embedded.

TRACK BOLT. A round steel bolt with a button head, an oval neck and a threaded nut designed to hold the members of a rail joint in place. The oval neck passes through a hole of similar shape in the joint bar and prevents the bolt from turning when the wrench is applied to the nut.

A track bolt is usually made of carbon steel or of alloy steel, and is frequently heat-treated and oil-quenched to increase its strength. In order to hold joints tight under the jar of rolling loads, the nut is turned on the bolt with a strong pull, for which a track wrench as long as 33 in. is frequently used. To withstand such a pull without stretching, the bolt should have an elastic limit of 35,000 lb. to 45,000 lb., and an ultimate strength equal to twice the elastic limit. As the strength varies directly with the diameter of the bolt it is important to use bolts of as large diameter as the rail section and joint bars will permit.

The length of a bolt is measured from the point to the under side of the head. The bolt should be long enough to pass through the joint bars, the web of the rail, the nut lock or other locking device and the nut, so that when it is screwed home on the bolt there will remain about two threads at the end outside the nut. If the bolt is too long the nut may reach the inner end of the threaded portion before the bolt is tight on the joint, in which case washers are necessary; while if it is too short, full service is not obtained from the threads. One advantage of the use of nut locks on track bolts is that they tend to prevent the battering of the threads of the bolts against the sides of the hole in the rail.

The diameters of bolts in common use range from ¾ in. for 60 lb. to 80 lb. rail, ⅞ in. for 80 lb. to 100 lb. rail, 1 in. for 100 lb. to 110 lb. rail and 1⅛ in. for 120 lb. and heavier rail, although all railways do not follow the same standard in this respect.

Four or six track bolts are used in a joint according to the design of the joint, the four bolt joint being more common since broken joint track and suspended joints have come into general use. In fastening a rail joint, the heads of the first and third track bolts are commonly placed on the outside, and the heads of the second and fourth bolts on the inside of the track to prevent a derailed flange from stripping all the nuts from a joint.

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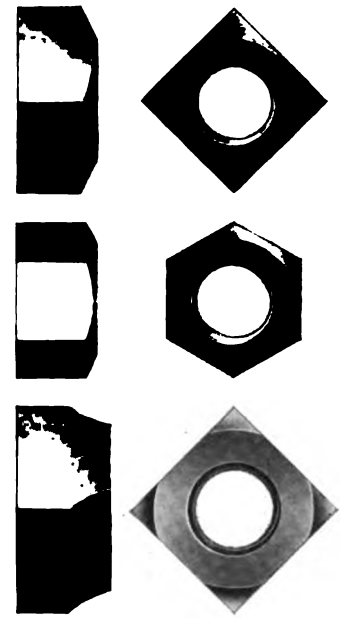
On account of the movement of the rail under traffic, of expansion due to changes in temperature and various stresses developed in use, track bolts must be carefully made to fit all the parts of the joint. The bolt should be just loose enough in the bolt holes of the joint bars and rails to permit half the requisite expansion space between the rail ends. It should be threaded to a snug fit for the nut in order to avoid stripping.

1. U. S. Standard Rolled Thread Track Bolt and Square Nut

2. U. S. Standard Cut Thread Track Bolt and Hexagon Nut

3. Buttress (Harvey Grip) Rolled Thread Track Bolt and Recessed Square Nut
(See Page 717)



Track bolts should be oiled carefully before shipping and periodically oiled and kept clean when carried in railway stock. It is considered good practice to oil track fastenings periodically and especially the bolts and nuts, either by hand or by means of special apparatus, to prevent rust and preserve the threads while in service. Bolts and nuts should also be oiled after removal from track to prevent rusting while not in use. They are commonly shipped in kegs of 200 lb.

The common form of track bolt has either cut or rolled threads. Bolts with cut threads have less ultimate strength, although there is no difference in the elastic limits of bolts with cut and rolled threads. Bolts are commonly manufactured with either the U. S. standard or the buttress thread, both of which are either cut or rolled. The U. S. standard is a V-shaped, symmetrical thread. The buttress thread, otherwise known as the Harvey grip, is an acute angle locking thread with which a recessed nut is commonly used without a nut lock or other washer. It is not a V-shaped thread but the point of the thread is inclined toward the head of the bolt 5 deg. beyond the horizontal. The thread of the nut on the bearing side is inclined 90 deg. to the aperture axis so that it binds the bolt threads and forces them back the 5 deg., thus locking the nut on the bolt. The nut is recessed on the bearing disc to protect the threads from chafing on the edges of the bolt hole.

The nuts should not be thinner than the diameter of the track bolt and may be either hexagonal or square. The hexagon shapes are lighter in weight, easier to tighten and require less clearance space at the angle of the joint bar, but are more expensive to make than the square nut. The square nut has the advantage of greater strength at the corners and better purchase for a wrench, while the extra metal is additional protection against wear. A recessed nut has a depression about 3/16 in. deep and of slightly greater diameter than the bolt, to insure one or two unused bolt threads on which to tighten the nut when the joint has loosened from the stretch of the bolts or from other wear.

The following general principles have been adopted by the A. R. E. A. for consideration in the design of track bolts:

As a rule, as large track bolts should be used as the rail and splice bars will permit. Bolts with rolled threads show a greater ultimate strength than those of the same size with cut threads. The elastic limit, however, is not materially different.

A workman pulling on a 33-in. wrench with a pull of 100 lb. will load a ⅞ in. diameter bolt to the extent of 45,000 lb. per square in. where the threads are in average condition. Therefore, it is easy to see how a bolt with a low elastic limit will readily be stretched in being tightened.

A ⅞-in. bolt with an elastic limit of 45,000 lb. will require the same pull to stretch it as a 1-in. bolt with an elastic limit of 35,000 lb. Again, a 1-in. bolt with an elastic limit of 75,000 lb. requires over twice the pull to stretch it as a 1-in. bolt with an elastic limit of 35,000 lb.

SPECIFICATIONS FOR TRACK BOLTS (A. R. E. A.)

Material. Steel shall be made by the open-hearth or other approved process. If necessary to secure the properties desired the bolts may be heat-treated.

Physical Properties and Tests. Bolts shall conform to the following requirements:

For carbon steel: Elastic limit, not less than 35,000 lb. per sq. in. Elongation, not less than 25 per cent in 2 in. Reduction of area, not less than 50 per cent.

For untreated nickel or other alloy steel: Elastic limit, not less than 45,000 lb. per sq. in. Elongation, not less than 20 per cent in 2 in. Reduction of area, not less than 40 per cent.

For heat-treated nickel or other alloy steel: Elastic limit, not less than 75,000 lb. per sq. in. Elongation,

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not less than 15 per cent in 2 in. Reduction of area, not less than 40 per cent.

The elastic limit shall in no case be less than 50 per cent of the ultimate strength. The elastic limit, elongation and reduction of area may be determined on a finished bolt or on a test piece ½ in. by 2 in. turned from a finished bolt. The ductility of the bolts shall be determined by the cold bend test, which requires that the material used in the bolt shall bend cold through 180 deg. and flatten itself without fracture on the outside of the bent portion. This bend may be made on the unthreaded portion of a finished bolt, on a blank bolt or on a test piece of the same size and grade of steel, in any case subjected to the same treatment as the finished bolt. It is not necessary that the bolt bend double in the threaded portion. A sufficient number of tests shall be made to satisfy the inspector that the material meets the specifications in every respect.

Workmanship and Finish. Subject to the following allowances, track bolts shall conform to the drawing submitted to the manufacturer: The length shall not be less than $\frac{1}{16}$ in. less or ⅛ in. more than the dimension shown. The diameter of the bolt shall not vary more than $\frac{1}{64}$ in. from the dimension shown. The size of the head shall not vary more than $\frac{1}{16}$ in. from the dimensions shown. The outside dimensions of the nut shall not vary more than $\frac{1}{32}$ in. from the dimensions shown. The shoulder of the bolt shall not vary more than $\frac{1}{64}$ in. from the dimensions shown.

The heads and nuts shall be free from checks or burrs of any kind. They shall have the U. S. standard upset thread unless otherwise specified. The threads may be either cut or rolled and shall be full and clean, with not less than two, nor more than five finger threads. Care must be taken to avoid damage to the metal by overheating in manufacture.

Inspection. When required, the manufacturer shall furnish samples of bolts from a preliminary rolling before proceeding with the filling of the order and give sufficient notice in advance of the date when they will be ready for inspection. The inspector representing the purchaser shall have free entry at all times, while the work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The inspection shall be made at the mill and the manufacturer shall afford the inspector free of cost all reasonable facilities to satisfy himself that the bolts are being furnished in accordance with these specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Tests of the finished product shall be made of samples selected by the inspector from each lot of 100 packages. Two pieces shall be selected for each test, and if both meet the requirements of the specifications the lot will be accepted. If one of the test pieces fails, a third test piece shall be selected and tested; if it meets the requirements of the specifications the lot will be accepted, but if it fails the lot will be rejected. If after shipment any bolts are found to be defective due to material or manufacture, they may be rejected.

Marking and Shipping. When the bolts are shipped they shall have the nuts applied for at least two threads, shall be properly oiled to prevent rusting, and shall be packed in good, serviceable packages. All packages must be plainly marked as to material, size of bolts and name of manufacturer.

Specifications for Medium Carbon Steel Track Bolts With Nuts

1. **Access to Works.** Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the bolts and nuts have been made in accordance with the terms of the specifications.

2. **Place for Tests.** All tests and inspection shall be made at the place of manufacture, prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

3. **Rejection at Destination.** Bolts and nuts which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer, who shall pay the freight charges both ways.

4. **Material.** Material for bolts shall be steel made by the open-hearth or Bessemer process. It shall be homogeneous and when broken in tension shall show a uniformly silky fracture. Material for nuts shall be of soft steel.

5. **Chemical Properties.** The chemical composition of each melt of steel from which track bolts are manufactured shall be within the following limits:

Phosphorus, Maximum	Per Cent
Open-Hearth	0.05
Bessemer	0.10

6. The manufacturer shall furnish the inspector a complete report of ladle analysis showing carbon, manganese, phosphorus and sulphur content of each melt represented in the finished material and any other elements used to obtain the specified physical properties. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 5. The drillings for check analysis shall be taken parallel to the axis and from the end of the finished bolt.

7. **Physical Properties and Tests.** Track bolts shall conform to the following physical requirements:

(a) Tensile strength, lb. per sq. in., minimum 55,000

(b) Yield point not less than 50 per cent of the ultimate breaking stress..... $\frac{1{,}500{,}000}{\text{Ten. Str.}}$

(c) Elongation, per cent in 2 in., not less than .....Ten. Str. Minimum, 20 per cent. $\frac{2{,}200{,}000}{\text{Ten. Str.}}$

(d) Reduction in area, not less than..... Minimum, 30 per cent.

(e) Cold bending of the unthreaded part of the finished bolt without sign of fracture on the outside of the bent portion, through 180 deg. flat on itself.

8. All test specimens shall be from the finished bolts.

(a) The tension test specimens shall be about 4¼ in. long with threaded or unthreaded ends, and with the central 2-in. length turned to a ½ in. diameter, in accordance with the form and dimensions for tension test specimens of the American Society for Testing Materials.

9. **General Requirements.** Track bolts and nuts shall be made to dimensions specified in drawing furnished by the purchaser, with allowable variation in dimensions of bolts from standard as follows:

Length, ⅛-in.;
Diameter, 1/64-in.;
Shoulder, 1/64-in.;
Diameter of rolled thread not more than $\frac{1}{16}$ in. over the diameter of the body of ⅞-in. bolts;
Diameter of rolled thread not more than $\frac{1}{32}$ in. over the diameter of the body of 1-in. bolts;
Variation in dimensions of elliptical shoulders under head of bolt of $\frac{1}{32}$-in.

10. The heads and nuts shall be free from checks or burrs of any kind. All finished pieces shall be smooth, straight, of uniform size, with well-shaped symmetrical bends and well-filled heads, free from injurious mechanical defects, and be finished in a first-class, workmanlike manner. The head shall be concentric with and firmly joined to the bottom of the bolt, with the underside of the head at right angles to the body of the bolt. The threads on bolts shall be rolled, unless otherwise specified, shall be full and clean and shall be made in section and pitch according to the purchaser's standard. The fit between threads on the bolt and nut shall be accurate and nut shall go on with a 10-in. wrench from second to fifth turn. The force to turn the nut completely on the bolt with a 24-in. wrench shall not be more than 60 or less than 40 lb.

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11. The nuts shall be made of soft, untreated steel and shall be of sufficient strength to develop the ultimate breaking strength of the bolts.

12. **Branding.** Manufacturer's identification shall appear on the head of each bolt.

13. **Marking and Shipping.** When the bolts are shipped they shall have the nuts applied for at least two threads, be well oiled to prevent rust, and shall be packed in securely hooped kegs of 200 lb. net. All kegs shall be plainly marked as to material, size of bolts and name of manufacturer.

14. **Inspection.** Tension and bend tests shall be made of the test specimens selected by the inspector from each lot of 50 kegs. One specimen shall be selected for each test, and if they meet the requirements of the specifications the lot will be accepted. If one of the test specimens fails, two additional specimens shall be tested in the same manner as the one which failed, and if they meet the requirements of the specifications, the lot will be accepted. If, however, either one of the specimens fails, the lot will be rejected. Both tension and bend tests shall pass the requirements for acceptance.

Specifications for Quenched Carbon and Quenched Alloy Steel Track Bolts With Nuts

1. **Access to Works.** Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the bolts and nuts have been made in accordance with the terms of the specifications.

2. **Place of Tests.** All tests and inspection shall be made at the place of manufacture, prior to loading, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

3. **Rejection at Destination.** Bolts and nuts which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer, who will pay the freight charges both ways.

4. **Material.** Material for bolts shall be steel made by the open-hearth process or an acceptable alloy steel. It shall be homogeneous and when broken in tension, shall show a uniformly silky fracture. Material for the nuts shall be soft, untreated steel.

5. **Chemical Properties.** The chemical composition of each melt of steel from which track bolts are manufactured shall be within the following limit:

Phosphorus, per cent, maximum.....0.04

6. The manufacturer shall furnish the inspector a complete report of ladle analysis showing carbon, manganese, phosphorus and sulphur content of each melt, represented in the finished material and any other elements used to obtain the specified physical properties. The purchaser may make a check analysis from the finished material; such analysis shall conform to the requirements of Section 5. The drillings for check analysis shall be taken parallel to the axis and from the end of the finished bolt.

7. **Physical Properties and Tests.** Track bolts shall conform to the following physical requirements:

	Carbon Steel	Alloy Steel
(a) Tensile strength, lb. per sq. in., minimum	100,000	110,000
(b) Yield point, lb. per sq. in., minimum	70,000	85,000
(c) Elongation, per cent, in 2 in., not less than	$\frac{1,600,000}{\text{Ten. Str.}}$	

Minimum, 12 per cent.

(d) Reduction to area, per cent not less than $\frac{3,500,000}{\text{Ten. Str.}}$

(e) Cold bending of the unthreaded portion of the finished bolt without fracture on the outside of the bent portion through 90 deg. around an arc, the diameter of which is three times the thickness of the test specimen.

8. All test specimens shall be from the finished bolts.

(a) The tension test specimens shall be about 4¼ in. long with threaded or unthreaded ends, and with the central 2-in. length turned to a ½-in. diameter, in accordance with the form and dimensions for tension test specimens of the American Society for Testing Materials.

(b) The yield point shall be determined by the strain gage.

9. **Quenching.** (a) Track bolts shall be treated by quenching in oil or water, if so specified, from a temperature of about 810 deg. Centigrade (1490 deg. Fahrenheit) and shall be kept in the bath until cold enough to be handled; a group thus treated being known as a quenching charge.

(b) Material which requires quenching in water will be acceptable at the option of the purchaser, provided it meets the requirements of the specification in all other respects.

10. **General Requirements.** Track bolts and nuts shall be made to dimensions specified in drawing furnished by the purchaser with allowable variations in dimensions of bolts from standard as follows:

Length, ⅛-in.;
Diameter of shank, 1/64-in.;
Shoulder, 1/64-in.;
Diameter of rolled thread not more than 1/16-in. over the diameter of the body of ⅞-in. bolts;
Diameter of rolled thread not more than 3/32-in. over the diameter of the body of 1-in. bolts;
Variation in dimensions of elliptical shoulders under head of bolt of 3/32-in.

11. The heads and nuts shall be free from checks or burrs of any kind. All finished pieces shall be smooth, straight, of uniform size, with well-shaped symmetrical bends and well-filled heads, free from injurious mechanical defects, and be finished in a first-class, workmanlike manner. The head shall be concentric with and firmly joined to the bottom of the bolt with the underside of the head at right angles to the body of the bolt. The threads on the bolts shall be rolled, unless otherwise specified, shall be full and clean and shall be made in section and pitch according to the purchaser's standard. The fit between threads on the bolt and nut shall be accurate and nut shall go on with a 10-in. wrench from second to fifth turn. The force to turn the nut completely on the bolt with a 24-in. wrench shall not be more than 60 nor less than 40 lb.

12. (a) The nuts shall be made of soft untreated steel and shall be ¼-in. thicker than the standard nuts used for untreated bolts. They shall be of sufficient strength to develop the ultimate breaking strength of the bolts.

(b) Nuts of standard thickness will be accepted at the option of the purchaser if proved to be of sufficient strength to equal the ultimate breaking strength of the bolts. The length of the bolts shall be correspondingly reduced.

13. **Branding.** The heads of the bolts shall bear the manufacturer's identification symbol. The letter Q shall be used to show that the bolts have been quenched. If the bolts are also tempered, the letters QT shall be used to show that they have been quenched and tempered.

14. **Marking and Shipping.** When the bolts are shipped they shall have the nuts applied for at least two threads, be will oiled to prevent rust, and shall be packed in securely hooped kegs of 200 lb. net. All kegs shall be plainly marked as to material, size of bolts and name of manufacturer.

15. **Inspection.** Tension and bend tests shall be made of the test specimens selected by the inspector from each lot of 50 kegs. One specimen shall be selected for each test, and if it meets the requirements of the specification, the lot will be accepted. If the test specimen fails, two additional specimens shall be tested in the same manner as the one which failed, and if they meet the requirements of the specification, the lot will be accepted. If, however, either one of the pieces fails, the lot will be rejected. Both tension and bend tests shall pass the requirements for acceptance.

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TRACK CHISEL. A hammer-shaped, hard steel cold chisel with a wooden or steel handle, used by trackmen for cutting rail and other metal.

Track Chisel Hot Cutting Chisel
(See Pages 706, 829 and 832)

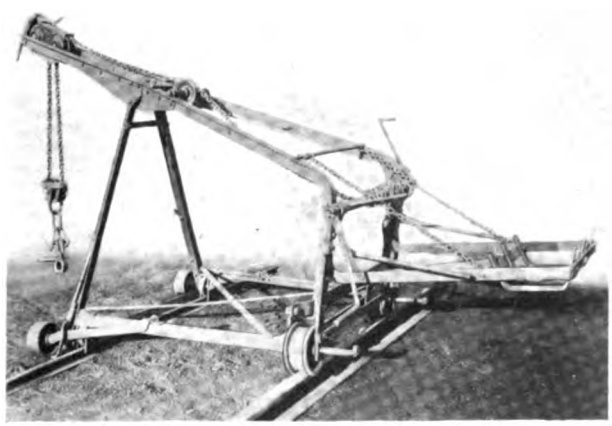
The front and back faces of the chisel are parallel plane surfaces, the eye for the handle being about 3 in. below the striking face, while below the eye the sides converge convexly to a bluntly beveled, slightly arched cutting edge which is parallel with the handle; permitting the holder, stationed on one side of a rail, to keep the edge on a line marked around it while the striker hits the chisel with a maul as it is set at the end of each successive nick, until a deep groove is cut all around the rail, which is then broken at the chiseled line by raising and dropping it with the groove across another rail. Another type of track chisel commonly used has a peen or cutting portion which is long, flat and narrow with a rounded, sharp and bluntly beveled cutting edge and a squared striking face with beveled corners.

TRACK CROSSING. An arrangement of frogs whereby traffic on either of two tracks which intersect at grade may proceed across the opposing track. Four crossing frogs are necessary for a crossing, one for each of the four rail intersections. See Frog.

TRACK LAYING MACHINE. A machine designed to minimize the manual labor of placing rails, fastenings and sometimes the ties of a railway track.

Track laying machines are made on wheels and axles of standard gage or on cars with standard trucks. They are classified according to use as (1) maintenance track layers and (2) constructions machines.

A maintenance of way track laying machine commonly consists of a crane mounted on a platform or on small flanged wheels. The loads are lifted by means of a windlass cable or chain and block to which a rail hook is attached. This device is designed to be readily removed from the track and to be operated by a small section gang, especially to relay short strings of rail which would otherwise be placed by hand, the work not being of sufficient extent to warrant the attention of an extra gang. These machines are likewise used on maintenance to relay extensive mileages of rail, their portability being advantageous while the combining of section gangs for the work eliminates the necessity for organizing and maintaining large extra gangs.



Three Man Track Layer
The Maintenance Equipment Co.
(See Page 739)

A construction track laying machine is an arrangement of mechanical attachments on railway construction cars by means of which track may be laid with rails and ties which are unloaded directly from the forward end of a pioneer car at the front of a material train, which is moved ahead as the rails are laid and kept always at the end of the track. These attachments usually consist of a series of tramways and rollers, arranged in sections about 30 ft. long, supported on brackets attached to the stake pockets on the sides of standard flat cars on which the track materials have been loaded. The rail rollway is usually attached on the right side of the cars and the cross tie rollway on the left side, both being operated by chain drive or by power from a stationary steam engine located on the pioneer car. Instead of these rollways a tramway is sometimes laid over the tops of the flat cars on which push cars loaded with ties are run from the cars behind to the front, the rails of the tramway being counter-sunk so that the tops are flush with the top of the floor of the car. The ties are dumped from the push car over the end of the tramway track which, extending about twenty feet beyond the front end of the pioneer car, is held in position by overhead truss rods carried over a frame bent and anchored to the rear end of the car. With this arrangement the rails, usually carried on the first cars behind the pioneer car, are forwarded at car floor level outside the train track over a series of horizontal iron rollers to the pioneer car, on which is mounted a small derrick which lowers them to the ties, two lengths of rail usually being joined and lowered together. Still another arrangement forwards the rails and ties together on rollers located just inside the edges of the flat cars, the ties being carried ahead to the rail car, laid cross-wise and roughly spaced on top of the rails.

TRAILING POINT SWITCH. A switch in which the points face away from the direction of traffic.

The wheels of vehicles pass over the points of a trailing point switch after they have passed the frog. Trailing point switches are desirable because of the lessened danger of derailment involved in comparison with facing point switches. In case a trailing point switch is set for the wrong track the wheel flanges will push the point away from the stock rail, bending it inward or breaking it but creating little or no danger of derailment to the train running through it although trains moving in the opposite direction may be derailed on account of it. Bent switch point rails may sometimes be straightened temporarily without removal from service but ordinarily they are replaced and sent to the shop to be straightened and repaired.

TRANSVERSE FISSURE (Rail). An internal defect in the head of a rail, starting and spreading from an interior point where the continuity of the

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structure is broken, until the rail breaks almost square across, when the surface will show a bright oval spot with a well defined central nucleus.

The hidden danger of the transverse fissure has led to minute, long-continued but not decisive investigations as to the causes of the defeat. The transverse fissure is usually found in the head of the rail and in a vertical plane at right angles to the axis. Rarely, however, the fissure occurs in the base of the rail, or its top portion in the head of the rail may bend back about ½ in. beneath the surface. Frequently a rail will have several fissures in a length of a few feet. The prevalence of fissures is apparently of recent date, few such defects having been found in rails rolled earlier than 1909. Among the causes of the origin of fissures suggested by various authorities are the gagging of the rail in the mill, the finishing of high carbon rails at low temperatures, too few passes in the rolling, resulting in lack of even texture in the metal, segregation spots, slag inclusions, internal strains due to unequal cooling, overloading and alternate reverse bending stresses. It seems reasonable that the last two causes may rather contribute towards ultimate failure of rails affected with internal fissures which originated in some other manner. Some investigators have found internal fissures chiefly on the gage side of the rail, leading to the belief that the coming of the wheels and consequent heavier loads on the gage side are to blame, while others suggest incorrect counterbalance of locomotive drivers. Experiments have shown that all rails of a heat are likely to be affected and that it is advisable to locate and remove from track all rails of a heat as soon as any rail of that heat is known to have developed a transverse fissure.

TUNNEL. A passageway for railway trains excavated under ground or water where alternate construction such as an open cut or a bridge is not feasible or suitable.

An advantage of a tunnel is that it usually completes a short line to an objective point otherwise inaccessible except by circuitous routes involving serious operating obstacles, such as heavy curvature and adverse grades, or water terminals. Disadvantages of a tunnel are that it permanently restricts clearances, while ventilation is always a serious problem and drainage is sometimes a source of difficulty. It is advisable to restrict the gradient through a tunnel to that needed to provide drainage, terminating the steep approach grades, if any, outside the portals in order to minimize the smoke and gases emitted from the stacks of locomotives while passing through the tube. If a summit in a tunnel is unavoidable it is preferably located at or near one end, so that locomotives proceeding in one direction may shut off steam before entering. Any curve or grade that would obstruct the line of sight between the portals is preferably avoided, careful consideration being also given to the provision of air currents to clear the tunnel of smoke quickly with a view to obtaining the best ventilation.

The most favorable material for tunneling is sound rock which is durable enough to withstand the action of air and moisture, as disintegration of the strata penetrated necessitates artificial lining of the walls and roof. Permanent tunnel linings are preferably made of concrete, but sometimes of brick or stone masonry. The roofs of brick-lined tunnels are made of vitrified brick set in Portland cement to withstand the action of gases from locomotive stacks. In long tunnels regard should also be had for the location, where practicable, of intermediate shafts and drifts between the portals to ascertain the character of the strata, to provide additional starting points for excavation and for pumping out water and to furnish ventilation and light.

The usual form of tunnel section is a high walled arch of dimensions sufficient to provide room for smoke and gases above the sides of cars and locomotive cabs. The minimum cross section of a straight tunnel for a single track railway is given by the A. R. E. A. as 14 ft. in width at the top of the rail and 16 ft. in width at a height of 14 ft. above the rail, from which latter elevation a semi-circle 16 ft. in diameter, connecting the tops of the side walls, completes the section. In case the material of the walls will stand without slope, the width at the level of the top of rail is increased to 16 ft. while on curves the dimensions stated are increased and the track laid off center to provide the vertical straight track clearance. The minimum double track cross section is obtained by widening the single track section to conform to the railway's standard width between tracks, and providing an elliptical roof section to correspond.

The drainage in double track tunnels is preferably carried in a concrete channel midway between the tracks. The height of the rail is assumed to be 6 in. in all cases, the sub-grade being 2 ft. below base of rail in single track tunnels and 3 ft. below base of rail at the center line in double track tunnels.

TUNNEL DIAGRAMS. See Clearance.

TUNNEL PORTAL. The arched end opening which forms the gateway of a tunnel, including the surrounding courses of masonry, if any, used to provide the outside finish to the entrance.

The portals of a tunnel commonly mark the terminations of deep open cuttings.

TUNNEL SHAFT. A pit or well sunk from the surface of the ground above into a tunnel to furnish ventilation or light, or to provide an intermediate working point between the portals during construction.

Shafts are commonly vertical but when the tunnel is near a sloping surface they are sometimes dug horizontally from the side. They are ordinarily circular but are sometimes square, the sides are lined only when the material demands support and the tops and bottoms are usually protected by gratings or some similar safety device.

TURNOUT. A track arrangement extending from the point of the switch to the heel of the frog, by means of which engines and cars may pass from one track to another. The essential parts of a turnout are a switch, a frog, a pair of guard rails and a section of connecting track called the lead.

A turnout is right hand when it turns to the right, and left hand when it turns to the left as seen from the point of switch. A train is said to face the turnout when it approaches the switch point first, and to trail the turnout when it approaches the frog first. Thus, a train heading into a passing track faces the turnout and heading out of the siding trails the turnout. Trailing turnouts are preferred

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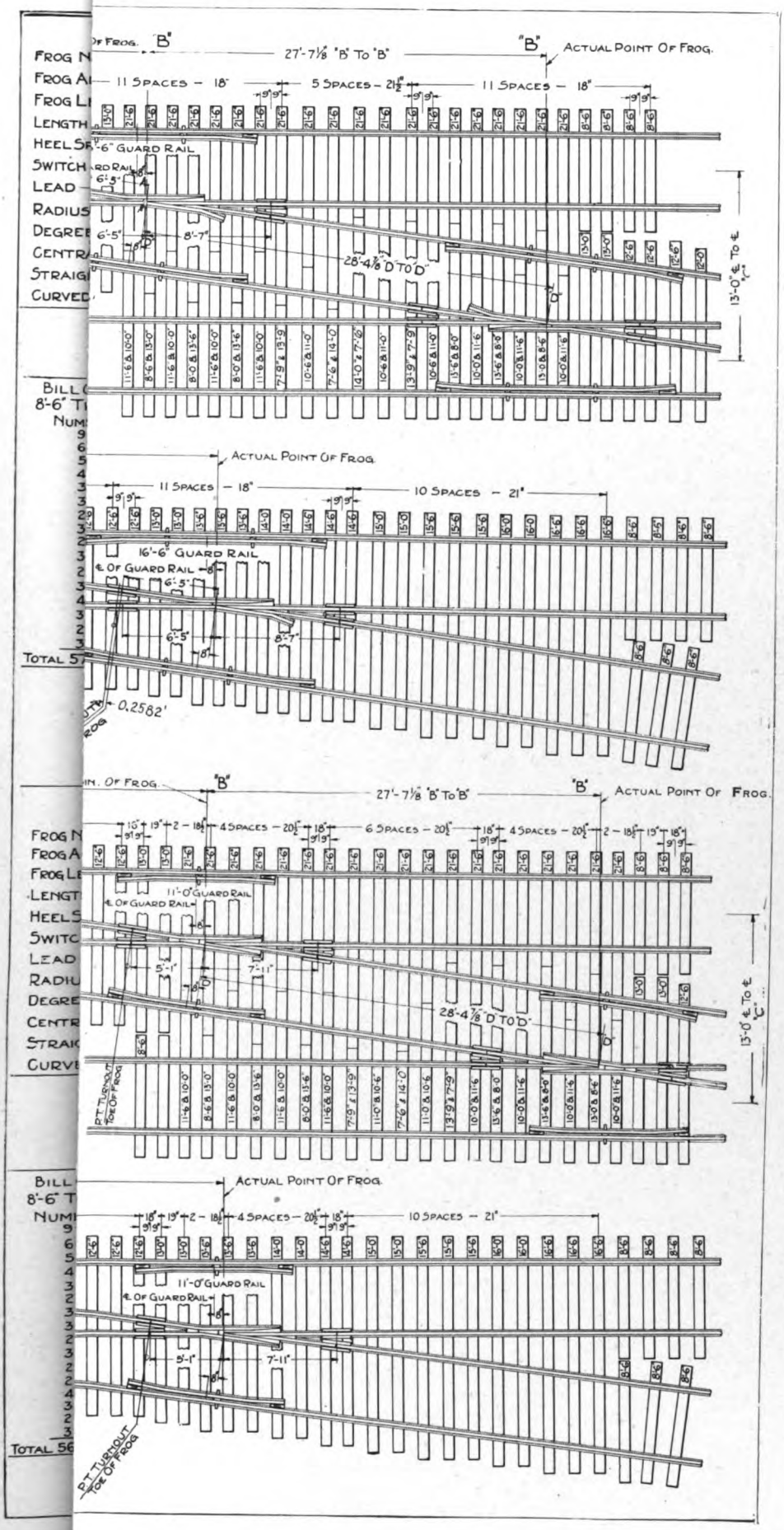

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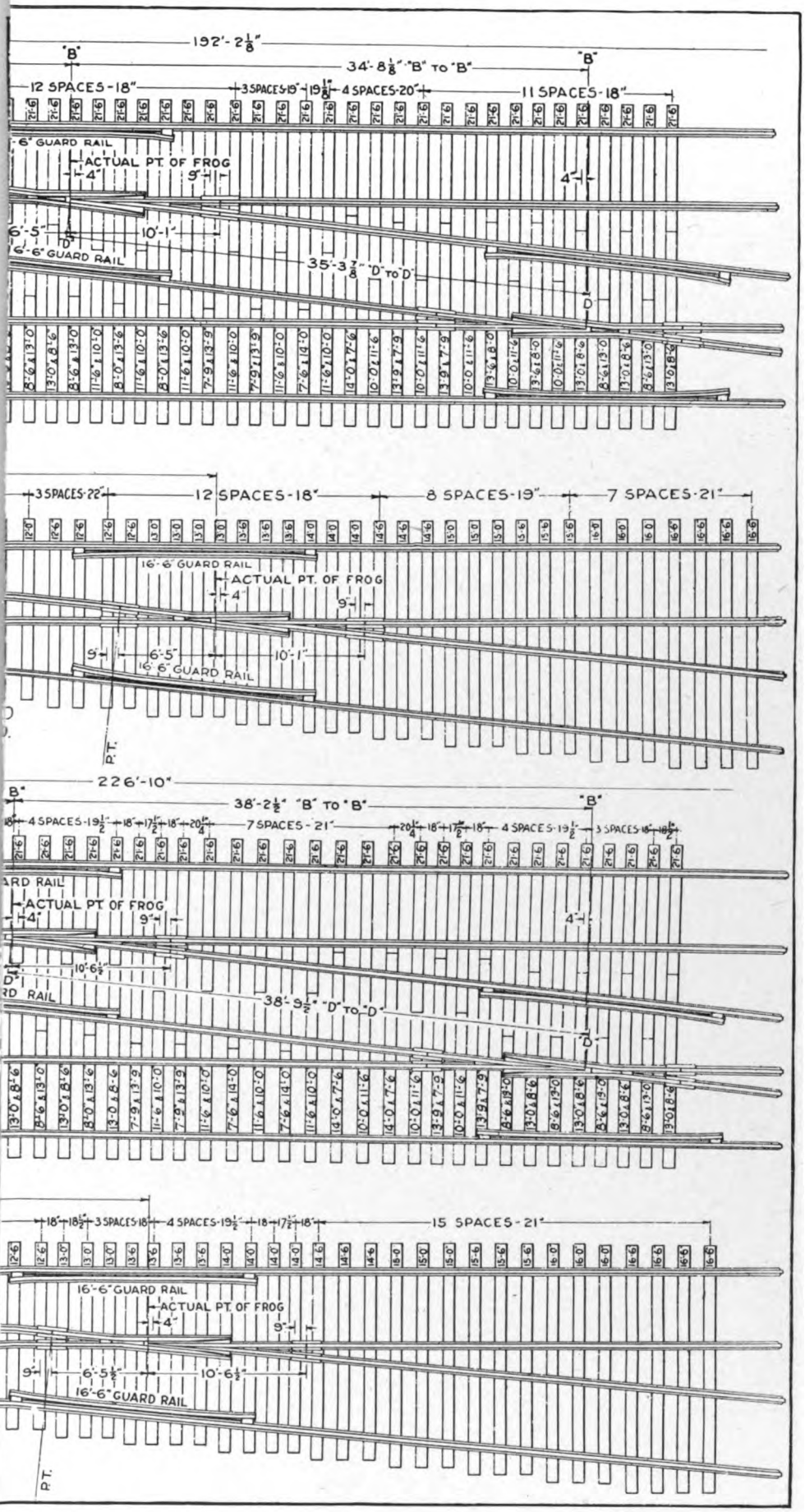

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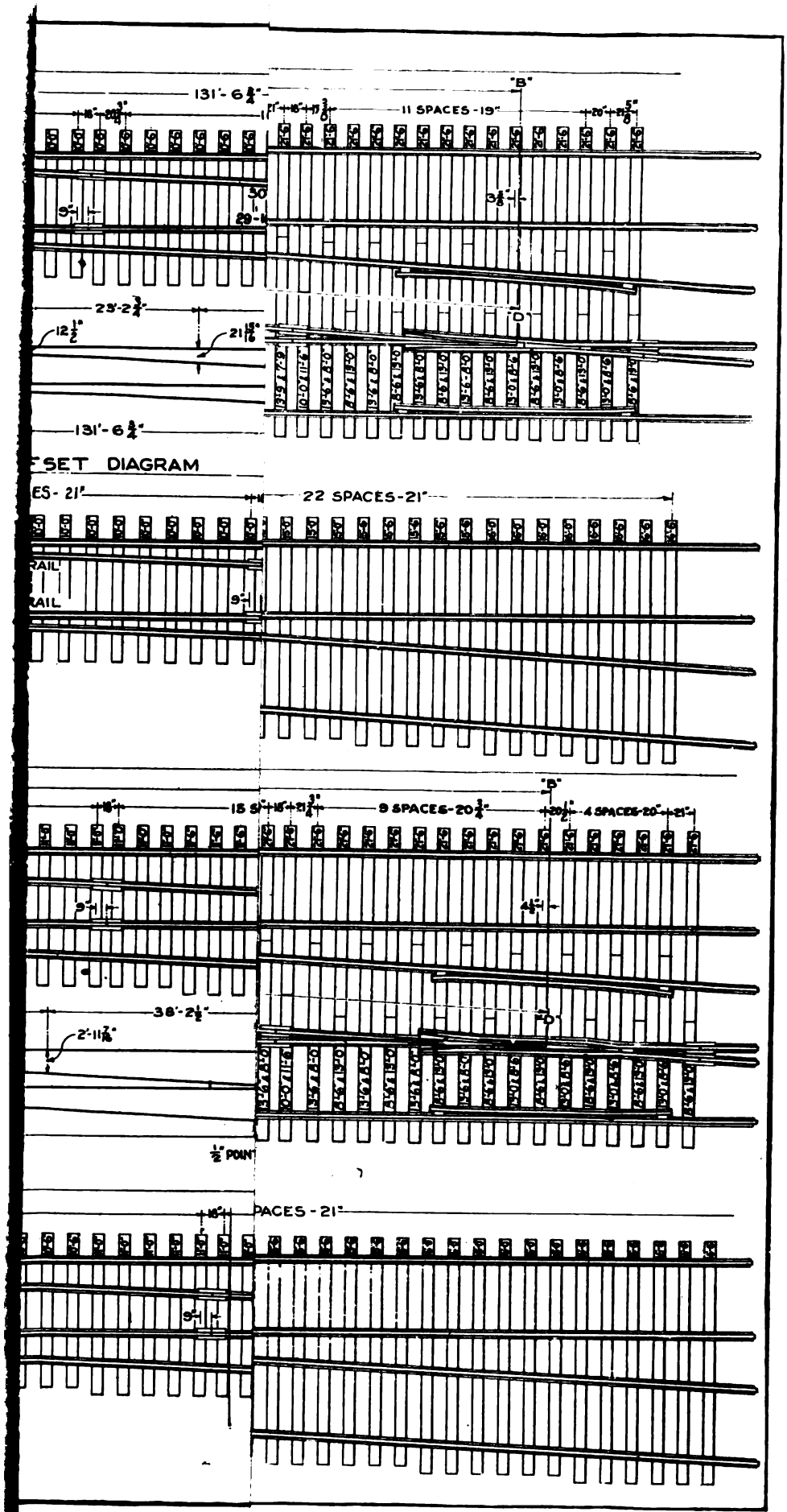

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on double track lines on account of the lesser danger of derailments.

The tendency of present practice is based on the demands of increased axle loads, higher speeds and more dense traffic. Automatic and semi-automatic turnout devices, turnouts of acute angles, crossovers and slip switches, hard alloy steel frogs, switch points and guard rails and improved fastenings are among the developments which are coming into such general use as to admit of probable early standardization.

It is considered good practice to reduce as far as possible the number of turnouts from main tracks.

Typical Track Turnout

To that end, yard and industrial tracks are commonly located to turn off from a lead track or siding built for that purpose where practicable. The same practice is frequently followed in locating industrial and other tracks off passing tracks at way stations. To prevent cars from fouling the main line some railways equip all such turn outs with derails, pipe connected to the switch stands.

It is considered good practice to locate the necessary turnouts on straight track wherever feasible, because of the short tangents introduced into curves by switches and frogs, because of the elevation of the switch rail above the stock rail on curves, because of the difficulty of maintaining the line, surface and super-elevation of curves at frogs, and on account of the limited visibility of the signal indications from switch targets and lamps on curves. If a turnout to a parallel track is located on the inside of a super-elevated curve, the super-elevation of the second curve of the turnout will be on the opposite side from that of the main curves on each side of it, while if a turnout is located on the outside of a curve the main track switch rail usually receives severe usage and must be watched closely to keep it in adjustment against the stock rail. A turnout from an ascending track introduces the element of danger from cars running out of the siding and fouling the parent track, unless the turnout is provided with a derail, which at best is a preventive involving an expenditure for rerailing cars. Lead tracks are frequently built for the express purpose of locating turnouts on straight track or inside the limits of interlockers, or to avoid placing them on steep grades.

The location of turnouts involves consideration of the economical cutting of rail, and the amounts of materials necessary for the work. Standard diagrams of turnouts from straight track are valuable to trackmen who have to order materials, especially as different types of frogs and lengths of switch rails require different lengths and total lengths of rail for the lead, different numbers of joints and sometimes several kinds of compromise joint bars.

The lack of uniformity in the design of the devices necessary to a turnout seems to be a natural result of individual effort to meet the diverse demands of traffic, involving dissimilar and varying combinations of speed and axle loads. Early types of frogs were made of four rail sections bolted together with light fillers and without reinforcement. Guard rails were bent with a rail bender on the ground and spiked to place by track men without fastenings to the running rail. The stub switch with the rail ends held in cast chairs was the forerunner of the reinforced split switch and its modern attachments. The one-piece head block, the cast iron switch-stand base and the one day switch lamp burner have all been replaced to a great extend as occasion required. Because of the ever-increasing demands of rapid transit it has not yet been possible to standardize switch materials. While the function of the turnout is to divert rolling stock from one track to another, the design and materials of manufacture depend very largely on the character of the rolling stock and the manner of operation.

TURNOUT GUARD RAIL. A flangeway rail placed opposite the frog of a turnout parallel with and fastened to the running rail as well as to the ties for the purpose of providing a groove between the adjacent rail heads to so guide a wheel as to keep its mate on the other end of the axle from fouling the otherwise unprotected point of the frog. See Guard Rail.

TURNOUT, MAIN LINE. A turnout diverging from the main track in which the frog and switch are located. See Turnout.

V

VELOCIPEDE, TRACK. A light three-wheeled railway inspection car designed to be propelled by one man and used principally by lamp tenders, telegraph linemen, watchmen, etc. Some velocipedes have seats for more than one person while the cross arm is fitted with a clamp to hold a tool tray.

This car, commonly known as a hand speeder, consists of a rectangular skeleton wood frame enclosing and resting on the axle bearings of two tandem wheels held upright by a cross-brace guide arm which ends in an axle bearing the third wheel, running on the opposite rail nearly in line with the front tandem wheel. The car is propelled by means of a double vertical hand lever and a pair of foot pedals, all geared to the rear wheel, in convenient position for the operator who sits astride the frame, alternately pulling and pushing on the cross-handles and pedals. The speed of the car is controlled by a hand brake on the rear tandem wheel, the controlling lever being between the vertical arms of the hand lever or on the side of the frame behind the opera-

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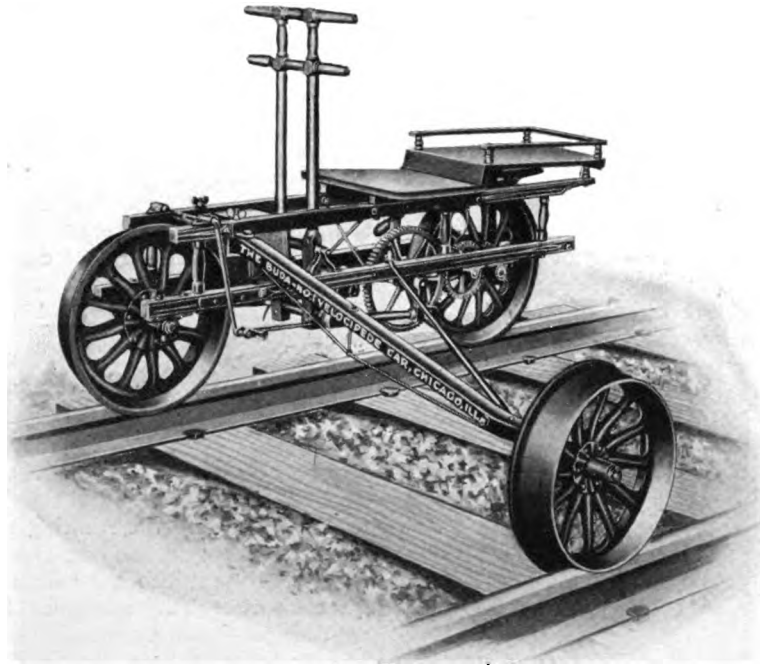
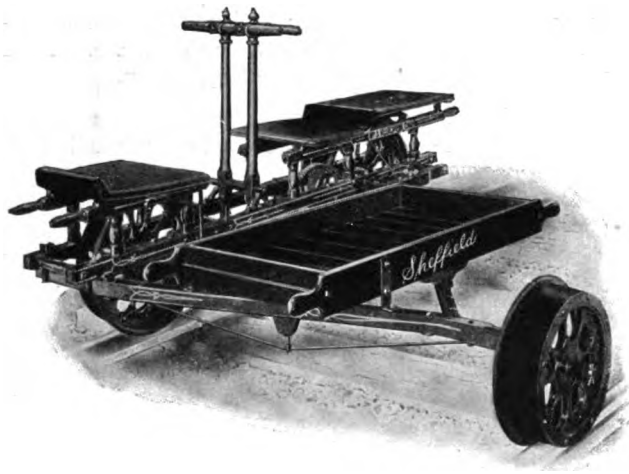
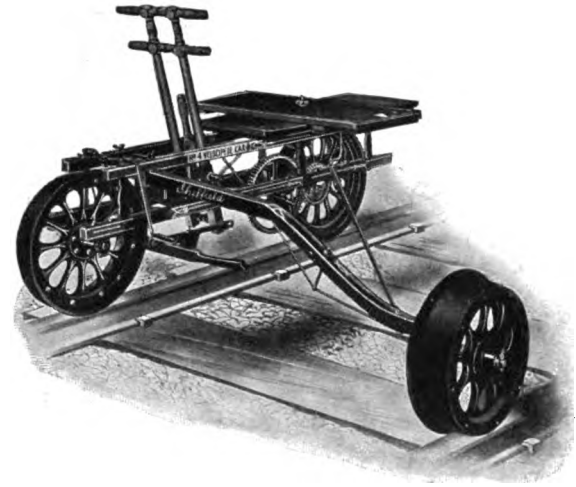


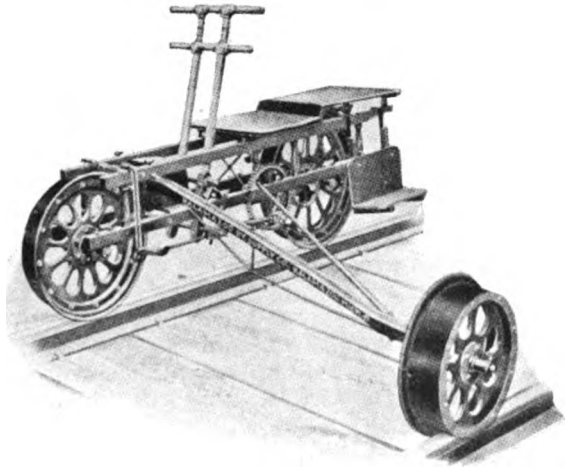
Buda Light Ball-bearing Velocipede
The Buda Co.
(See Page 659)



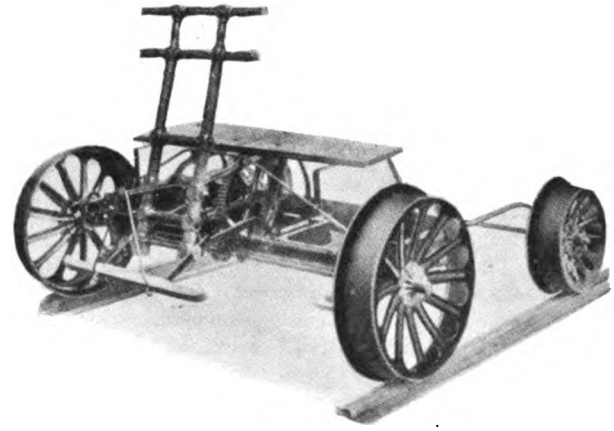
Sheffield Heavy Velocipede with Tool Tray
Fairbanks, Morse & Co.



Sheffield Light Pivoted Seat Velocipede Car
Fairbanks, Morse & Co.



Wood Frame Velocipede Car
The Kalamazoo Railway Supply Co.
(See Page 727)



All Steel Velocipede Car
The Kalamazoo Railway Supply Co.
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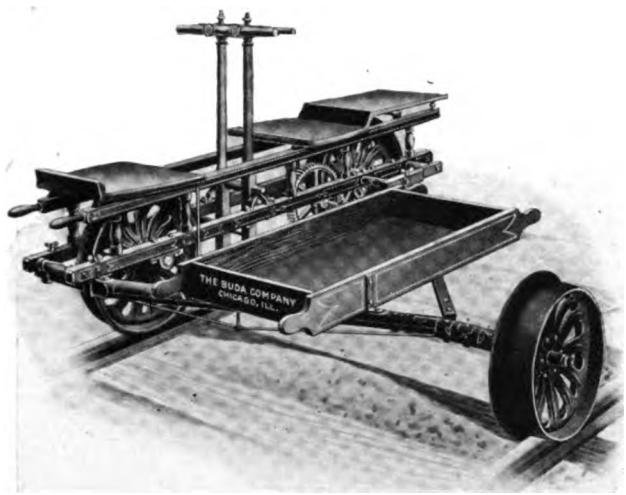


Buda Heavy Ball-bearing Velocipede with Tray
The Buda Co.
(See Page 659)

tor's seat. The wheels of cars operated through track circuits are insulated.

VERTICAL CURVE. A modification in the vertical angle formed at a change of grade by means of which the transition is effected gradually in a curved line.

Abrupt changes in gradients are avoided to prevent the tendency of the cars in a train to crowd or uncouple. A. R. E. A. standard practice is to introduce vertical curves of lengths determined by the gradients to be connected. On Class A lines maximum rates of change of 0.10 ft. per 100 ft. on summits and 0.050 ft. per 100 ft. in sags are stipulated, while on minor lines 0.20 ft. per 100 ft. on summits and 0.10 ft. per 100 ft. in sags should not be exceeded.

W

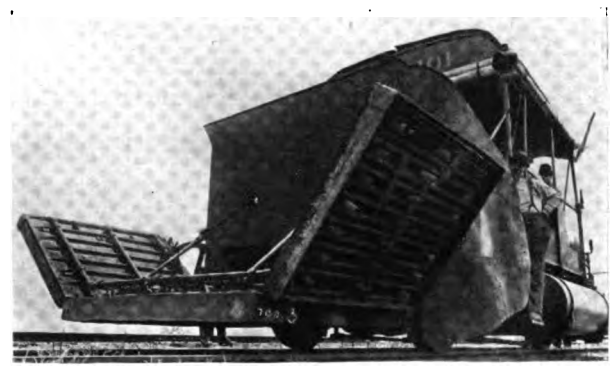
WASTE BANK. An embankment made outside the roadway to dispose of surplus materials from necessary excavations.

Waste banks are commonly placed back of surface drains dug at the tops of slopes of cuts, or below the level of the top of running rails on adjacent fills.

WATER POCKET. An undrained hollow in the top of a grade under a railway track, in which water collects and is retained.

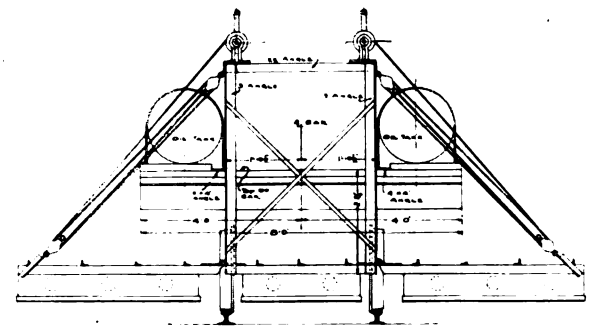
Water pockets form in depressions on improperly finished road beds, frequently due to unequal shrinkage, particularly in clay soil. Plowing, crowning and rolling the road bed to remove ruts, depressions and soft spots before laying the track and placing the ballast, tend to prevent the formation of such sink holes which, when started, gradually grow with the increase of wheel loads and traffic density, more settlement taking place under the track than on each side, as a result of which the ballast is crushed down into the road bed until it assumes a trough-shaped cross section. This condition can be remedied in embankments by cutting cross drains through the shoulders, laying small tile in them and filling the trenches with engine cinders or gravel. Crushed stone ballast is preferably underlaid with sub-ballast of engine cinders, which will not mix with clay. In excavations drain tile is frequently laid parallel with the tracks below the frost line and covered with engine cinders.

WEED DESTROYER. A device for mowing, or a gas or liquid for burning or poisoning weeds growing on the road bed. Weeds overgrowing the running rails tend to make locomotive drive wheels slip, while the moisture retained hastens decay in the ties and the dirt collected makes foul ballast. The problem of ridding the road bed of grass and weeds promptly gains importance because the growing season is the time when maintenance employes are busiest with track which should on no account be delayed, and the time generally required for scuffling weeds from the road bed (in some climates twice during a season) constitutes a serious setback in the maintenance program. The mechanical de-



Commonwealth Weed Burner
The Commonwealth Steel Co.

struction of weeds is commonly accomplished at actual running speeds of two to three miles per hour at which thorough clearing of the roadbed is possible, the usual daily progress allowing for traffic delays, being from 10 to 25 miles per day.



Weed Burning Car
The Macleod Co.

There are three general methods of destroying weeds: (1) by mowing, (2) by burning, and (3) by the use of chemicals. Railway motor cars equipped with mowing machine cutter bars and sometimes with harrows are adapted to clearing the vegetation from the shoulders of the road bed and the tops of embankment slopes.

A combination of adjustable gasoline burners and compressed air blowers with covers to deflect the

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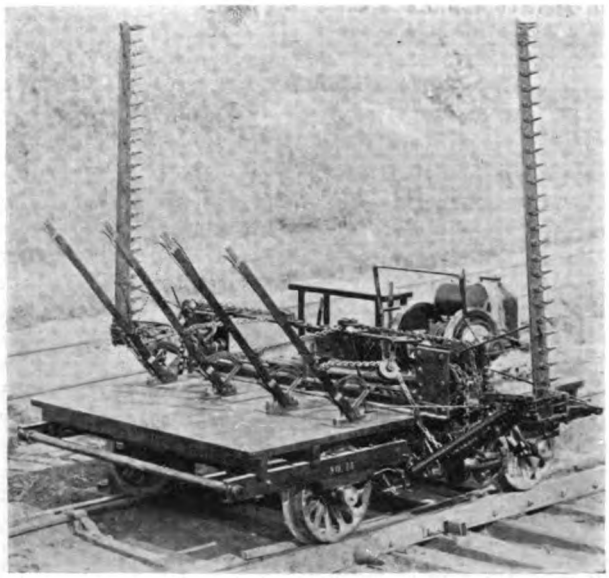
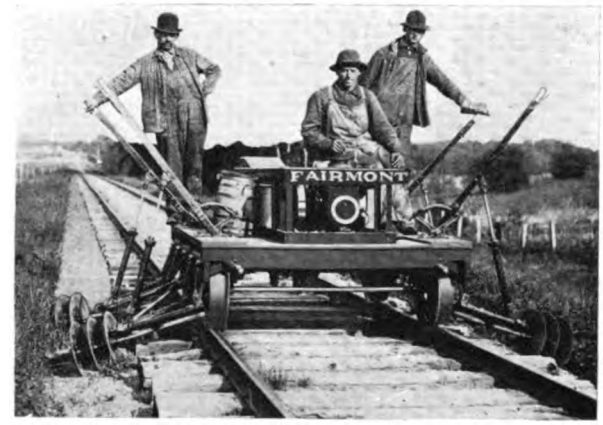
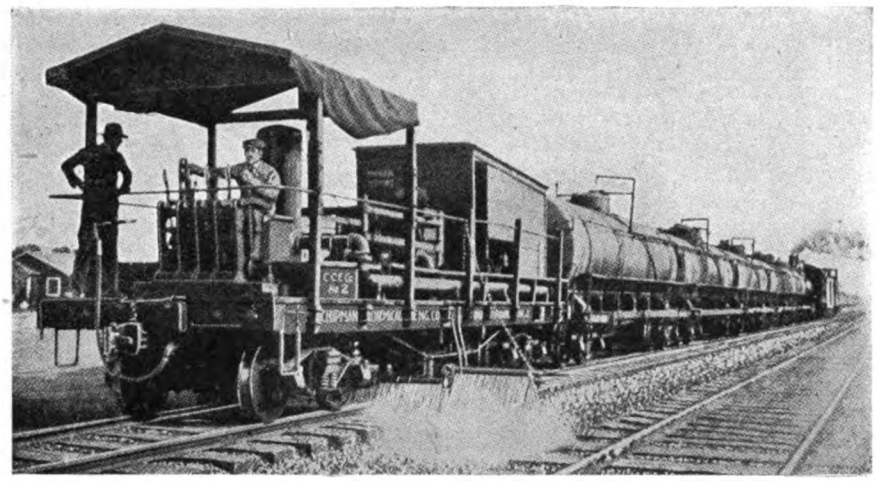


Fairmont Mowing Machine
The Fairmont Gas Engine & Railway Motor Car Co.
(See Page 692)



Fairmont Disc Weeder
The Fairmont Gas Engine and Railway Motor Car Co.



Atlas-A Weed Destroying Equipment
The Chipman Chemical Engineering Co., Inc.
(See Page 668)

Herbicide Weed Destroying Equipment
The Reade Manufacturing Co.
(See Page 786)

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heat downward constitutes the essential features of a weed burning car. The burners are usually built in three sections, each of which may be lowered close to the ground or raised as desired, while one or more burners may be turned on or off by the operator at any time. A further method of destroying weeds is the application of super-heated steam drawn from a locomotive and applied close to the ground by means of perforated pipes attached to and extendable from the underside of a specially fitted car.

Liquid chemicals which destroy weeds are commonly sprayed on the road bed from a sprinkler car fitted with compressed air, mixing tanks and a system of suitably perforated piping. The arsenical solution commonly used causes the vegetation to shrivel and die in a few hours after the spray is applied.

WICK RAISER, SWITCH LAMP. A device used to regulate the height of the wick, consisting essentially of a sprocket shaft fastened through the burner so that a sprocket or sprockets fastened to the shaft engage the wick. Shaft and sprockets are revolved to move the wick up or down to regulate the flame, by turning a milled edge button centered in the outer end of the shaft, which is usually extended through the metal casing so that it can be turned without opening the lamp.

WICK (Switch Lamp). A loosely woven ribbon, twisted rope or filled tube of felt, cotton or some spongy substance, used to draw the illuminating oil gradually from the fount through the burner to the flame. Kerosene forms crust when burning and the loose knit or felt tubular wick draws oil readily while the wick is consumed slowly. Circular switch lamp wicks generally are ¼ in. in diameter, while the flat ribbon wick is ⅝ in. wide. Both varieties are sold by the gross in lengths of about 8 inches or by the roll. See Wick, Switch Lamp, Center Core.

WICK, SWITCH LAMP, CENTER CORE. A switch lamp wick made by sewing together the edges of a ribbon of felt or cotton so as to form a cylinder around a central core of loosely twisted fibres, with the object of preventing incrustation by reason of the comparatively slow burning of the felt cylinder resulting in the formation of a small cup at the top of the wick, the oil feeding freely through the loose fibre core. It is used generally in switch and signal lamps with long-time burners.

WING RAIL FLARE. See Flare Opening.

WING RAIL OF FROG. The outside rail of a frog which serves as a running rail, converging from the toe to the throat of the frog, where it is sharply kinked so as to diverge toward the heel of the frog as a flared guard rail. The common turnout frog has two guard rails, one on each side of the point.

WING RAIL, STATIONARY. See Fixed Wing Rail. Also Frog.

WING VERTEX. See Frog. Also Throat of Frog.

WORKING POINT (Frog). See Actual Point of Frog.

WRENCH, TRACK. A steel spanner used to tighten the nuts on track bolts, with a view to holding the rail ends so firmly to the joint members that

Single Head Track Wrench
(See Page 733 and 830)

Double Head Straight Track Wrench
(See Page 733 and 830)

Double Head "S" Track Wrench
(See Page 733 and 830)

they act as a continuous girder. This wrench is also used to remove and renew the nuts. It is commonly a round bar, weighing 6 lb. to 10 lb., not more than 40 in. long, tapering from ¾ in. in diameter at the handle to 1 in. at the shoulder, whence it is flattened and spread to form wrenching jaws about ½ in. thick, whose inside faces fit three adjacent sides of a square nut or four adjacent sides of a hexagon nut.

Double head track wrenches are also generally used on some railways. These are usually ½ in. by 1½ in. flat, straight bars with rounded edges and with opposite working ends shaped to fit different sizes or shapes of nuts. In order to endure the wear of repeated leverage the wrench is preferably made of steel which is harder than the metal of the track nuts. The length of the bar is limited so that the leverage exerted by one man will not exceed the elastic limit of the track bolt. An advantage of the double head wrench is that the handle cannot readily be spliced and lengthened as is frequently done with the single head tool.

Y

YOKE. The principal holding member of a guard rail clamp. The yoke consists essentially of a one-piece metal bar with recurved ends. The central portion is designed to fit horizontally beneath and in contact with the bases of the running rail and the guard rail. The ends of the bar curve up and in toward the webs of the rails. Usually the yoke is forged from a heavy flat bar of steel. The ends are bent edgewise and the bar is used on edge to give the clamp maximum strength. See Guard Rail. Also Guard Rail Clamp.

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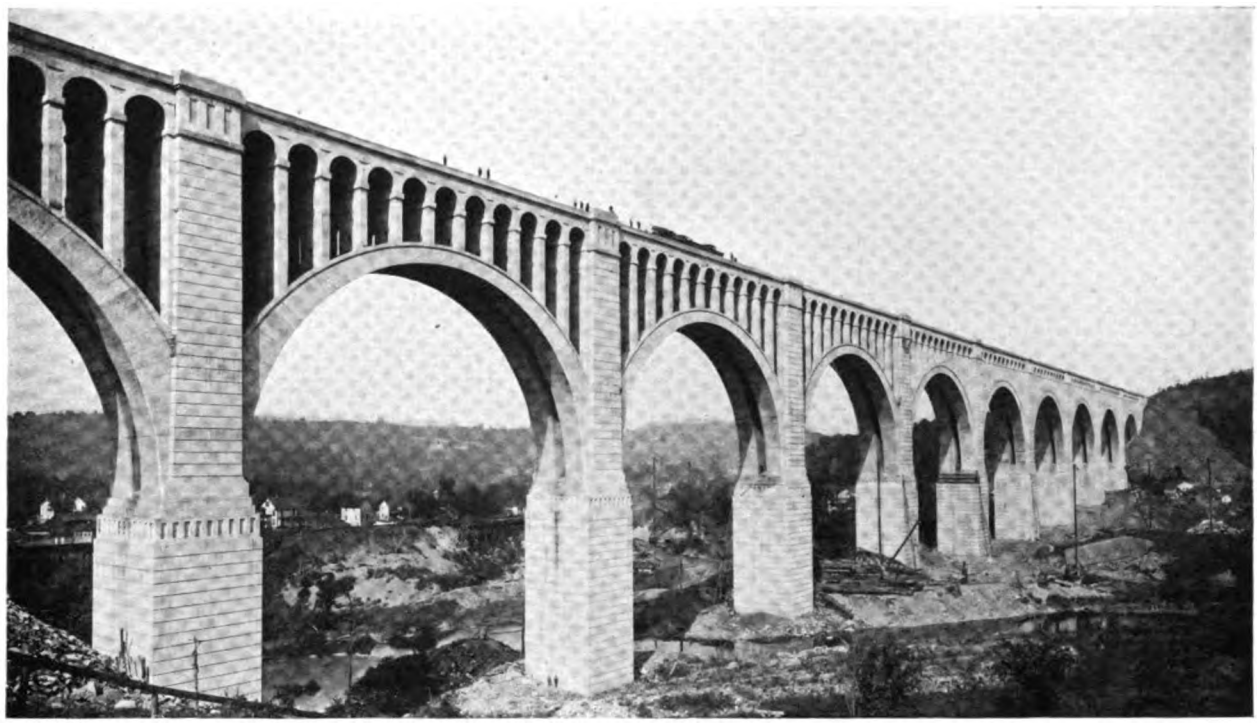

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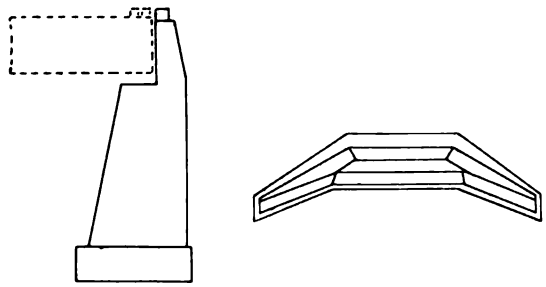
A

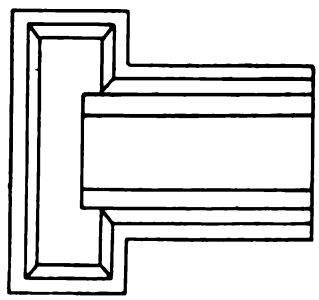
ABUTMENT, BRIDGE. A structure designed to support one end of a bridge, and usually to act also as a retaining wall for the end of the embankment which supports the track.

The abutment supports the end of the girder or truss on a shelf called the bridge seat and is constructed also with a view to protecting the embankment from water scour for which purpose it is frequently provided with side walls called wings, the entire structure being commonly of masonry. The various designs are classified as straight, wing, U- and T-abutments, according to the relative positions of the wings. The straight abutment is rectangular in plan, while the wing abutment terminates at either end in retaining walls which extend backward from the front face, usually at angles of 30 deg., while the copings decline to meet the slopes of the embankment which they are designed to retain. Although the 30 deg. angle is commonly the economical design, local conditions such as skew abutments and under crossings frequently demand modifications, both in angles and lengths of wings. The U-abutment has wings which extend backward at right angles to the face, forming parallel retaining walls at either edge of the road bed and taking the place of earth embankment slopes. The T-abutment is provided with an upright central slab extending back at an angle of 90 deg: from the line of its face. This slab, widened at the top and bearing the roadbed, is sustained laterally by the embankment while it supports and protects the abutment against water seeking its way along the back. Abutments are built with a view to stability against overturning, sliding and crushing their foundations, or the materials of which the structures themselves are composed. Care is exercised also to prevent water from undermining the structure or from seeping in behind it and softening or scouring the embankment. Where the bearing power of the foundation is insufficient, it is standard practice to increase the area of the base or to drive piling to help to support the structure. See Bridge.

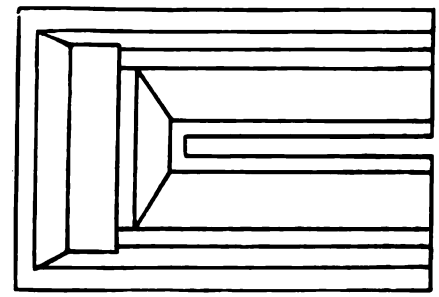
Concrete Wing Abutment



Wing Abutment



T-Abutment



U-Abutment

ANCHOR. To fasten permanently in a stable and secure position; as the cable ends of a suspension bridge, or the bases of tower posts of a steel viaduct to the footings or masses of masonry which hold them.

ARCH. A span of the cross sectional form of some part of the circumference of a circle or other curve.

The arch is one of the oldest forms of structural design, favored because of the readiness with which extensive structures of great strength may be formed of small blocks of material such as cut stone with or without mortar. A common type of small arch is semi-circular with low vertical or battered walls and a flat or slightly concave invert or floor; or the circular curve of the arch may be more than a semi-circle with extremities resting directly on the floor.

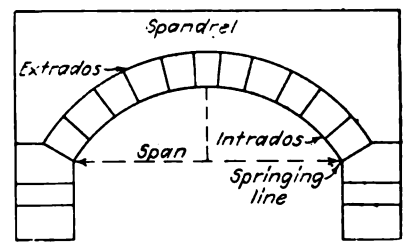


Diagram of Arch

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Multiple Concrete Arch Bridge

Steel Arch Bridge

Segmental Concrete Arch

Stone Arch Bridge

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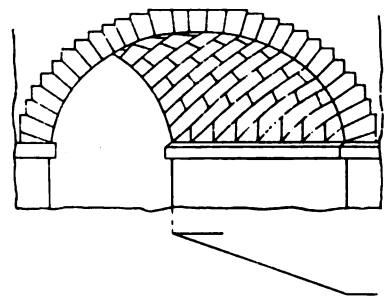
When wide, low spans are desirable the arch is constructed in segmental, elliptical or sometimes cycloidal form. The multiple arch, a design largely used in Europe for many years, is especially adapted to extensive railway bridges and viaducts where all-arch masonry construction is desirable rather than a high embankment over a simple arch of wide span. Reinforced concrete arches are constructed by means of centering which supports tight dressed and matched forms made practically water tight to retain the cement in the fresh concrete. Since the entire structure cannot be poured in one operation, joints must be left in the arch ring which is brought up from the springing lines equally on opposite sides until the two portions meet at the crown, unless the structure is very extensive when loading may be started at intermediate points and the construction carried toward the crown and the springing line at the same time, the object being to load the centering as symmetrically as possible during construction.

Five-Centered Concrete Arch Culvert

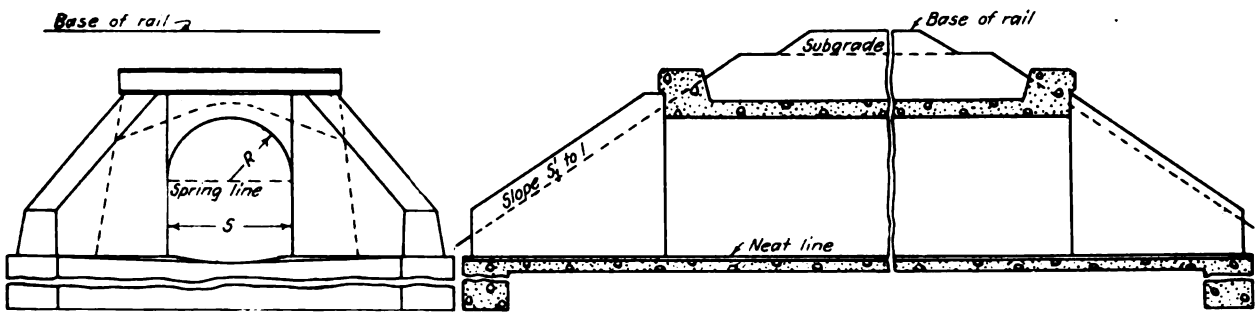
The joints left at the end of the day's work are always radial rather than horizontal and preferably rough surfaced rather than smooth. Stone masonry arches are composed largely of wedge-shaped arch stones, the center block placed at the crown of the arch being the keystone, and the lowest on each side the springers. Each arch stone is specially tooled, all stones in a string course being identical from end to end of the structure. The ring stones terminate these courses and differ from the string stones in having their outside faces finished. Arch stones are tooled and marked according to their designed location in the arch. Rectilinear stones or bricks are sometimes used in arch masonry, the ring being formed by placing the lower inside edges of the blocks in contact or nearly so while the upper outside edges are farther apart, the wedge-shaped spaces being filled with mortar while the forms support the entire outside surface or soffit until the mortar sets, when the forms are struck by removing the inside supports so that the sectional centers and sheathing will drop.

The excellence of an arch depends largely on the accuracy of construction, including the proper placing of the centers; on the rigidity of the sheathing, the centers and their supports; and on the care with which the units are placed as well as on the adequacy of the foundation. Concrete is especially adaptable to arch culvert construction, although the largest railway arch bridges are frequently built of fabricated steel.



Skew Masonry Arch

It is considered poor practice to load the haunches of an arch unequally. When an embankment is built over an arch it is brought to its full height in suitable layers placed simultaneously on both sides of



Concrete Arch

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Elliptical Arch

the structure, and over its entire length from spandrel to spandrel.

Extensive arch bridges of fabricated steel are sometimes erected on the cantilever principle, the con-

Semi-Circular Concrete Arch

struction being started from each end and continued until the two parts meet in the middle at the crown of the arch. See Bridge. Also Culvert.

ARCH CENTERING. The frame work or mold upon which the masonry of an arch is supported

Arch Centering

until the permanent structure is self supporting, when the centering is struck and removed.

Arch centering consists usually of regularly spaced parallel wooden ribs with outlines which follow the form of the intrados, and support a transverse covering of boards to complete the form of the barrel during the erection of the arch, while special forms are erected for the wings, spandrels, etc., of concrete structures. Arch centers are usually erected on wedges in order that removal of the wedges will release them so that they may be struck from within the finished structure, removed and re-used. See Arch.

ASHLAR. A squared or cut block of stone having rectangular dimensions, commonly used in masonry structures of the best class of construction.

The dimensions of a block vary with the class of stone used. With material such as sandstone and most kinds of lime stone, the length of the block should not be greater than three times its depth because of the tendency to break laterally under pressure; while granite, marble and the stronger classes of lime stone may be four or five times as long as the depth. See Masonry, Ashlar.

B

BACKING. The central or rear portion of a masonry wall as distinguished from the outside or face.

The backing is bonded to the face and consists usually of larger or rougher material. In stone masonry bridge abutments and piers the backing is usually large, well-shaped stone, roughly bedded and joined, the voids being thoroughly filled with concrete and spalls, the size of the stones depending on the thickness of the structure.

BAR, LACING. One of a series of short, flat steel bars placed diagonally across the open side of a built-up bridge member and riveted near the ends to the opposite flanges thus connected. They serve to connect the several elements which make up the member so that they will act as a unit in resisting bending or buckling. See Bridge.

BATTER. An inward slope from the base upward, applied to masonry walls, to the piles, posts and columns of bridges, etc., where the pyramidical design is used to increase the stability of the structure. For example, exterior faces of masonry walls are commonly battered from ½ in. to 2 in. to the foot while hand packed dry stone walls are usually battered ½ to 1, and the batter posts of bridge bents incline at 2 in. or 3 in. to the foot. See Abutment, Bridge. Also Pile.

BEAM. A structural member secured or supported at one or more points and loaded in a direction perpendicular or oblique to its length, as the stringer of a trestle bridge, or a girder.

BEAM, CANTILEVER. A beam so placed that one end projects beyond the point of support.

Railway bridges of various types are sometimes erected by the cantilever method, the construction usually proceeding from each abutment and adjacent supports, beyond which the two cantilever portions are projected until they meet in the middle to form a cantilever bridge, an arch, or other type of bridge. The cantilever principle is employed especially where falsework is not readily located, as over deep and swift streams. See Bridge, Cantilever.

BEAM, CONTINUOUS. A horizontal member of a bridge or other structure, having more than two points supported. See Beam.

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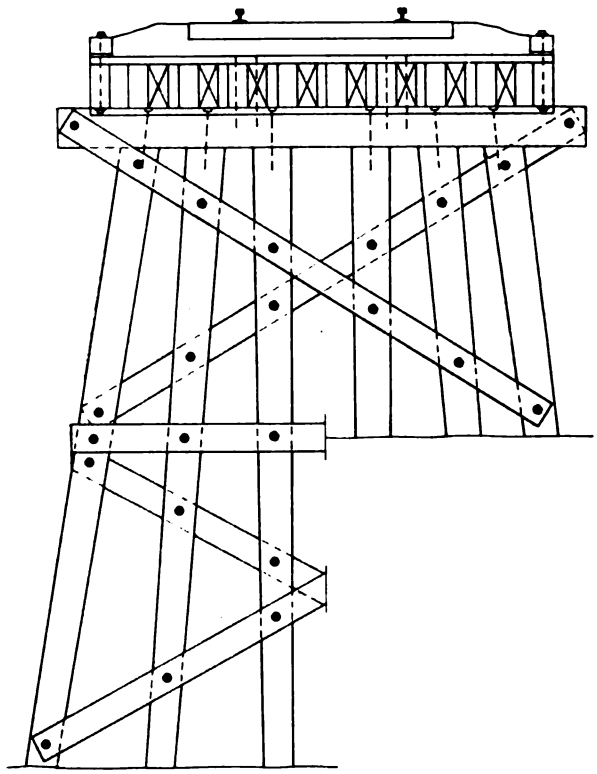
BEAM, SIMPLE. A structural member supported at two points and loaded in a direction perpendicular or oblique to its length. See Beam.

BED PLATE. A rectangular metal plate usually placed on the masonry footing of a steel bridge support to distribute the loads imposed and to protect the masonry from crushing.

The bed plate is of similar shape and greater surface area than the base of the post or column which it is designed to uphold. It is fastened on the top of the footing by means of holding-down bolts, commonly anchor bolts built into the masonry and threaded at their top ends for nuts.

BELTING COURSE. The course next below the coping course of a masonry bridge pier. See Bridge Pier.

BENT (Wooden Trestle). A group of members fabricated to form a single vertical support of a trestle bridge, which consists of two or more bents spanned by girders or stringer chords on which the



Pile Bent Diagram

deck is laid. Each bent commonly consists of four or more upright posts or piles, depending on the height of the bridge, the width of the roadbed and the weights of the loadings.

A framed timber bent has two or more plumb posts and two outside batter posts resting on a horizontal bottom sill and supporting a horizontal top timber or cap, while two crossed diagonal sway braces impart lateral stability. The outside posts are given a batter usually not less than 2 in. nor more than 3 in. in 12 in. vertical. In structures more than 28 ft. high it is common practice to build the bent in lifts of 12 to 14 ft. each successive lift resting on the intermediate sill which serves as the cap of the next lower lift. Usually the cap, sills and vertical members of a bent are timbers of nearly the same sections, the bottom sill resting on masonry, or on piling or posts, cut off just high enough above the ground to prevent decay through contact with earth or snow. Framed trestle bridges are usually made of 12-in. by 12-in. sawed timber, although round timber has been used in temporary trestle construction in some cases with marked success.

Pile bents commonly consist of two or more vertival piles, two outside batter piles, a cap and sway braces. As in the frame bent, the number of uprights depends on the height of the bridge, the width of the roadbed and loadings. The height of a pile bent is preferably less than 25 ft. above the ground. End bents of timber bridges usually consist of four or five capped piles cut off at about the line of the slope at the head of the embankment.

The 12-in. by 12-in. bottom sill is sometimes spliced if the height of the bent demands an unusually long base, the splice being preferably reinforced by top and bottom planks or timbers bolted through the sill. Planks usually about 3 in. thick by 8 in. or 10 in. wide are bolted or spiked diagonally across the bent from the upper side of the cap down to the bottom of the sill to stiffen the bent transversely. Two such sway braces are crossed to resist opposite forces, one being fastened across each face of the bent. Each story of a multiple lift bent is commonly supplied with two sway braces. See Trestle Bridge.

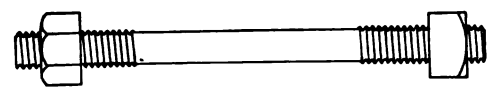
BODY (Pier). The main part of the pier between the foot and the coping. See Bridge Pier. Also Neatwork (Masonry).

BOLT, ANCHOR. A bolt used to hold a bridge superstructure in correct position on the substructure or bridge seats.

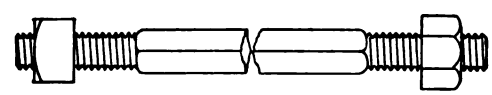
Anchor bolts may be placed in position at the time when the masonry is built or they may be inserted in drilled holes after the superstructure is placed on the substructure. In this case they are usually of some expansion type and are grouted in.

BOLT, BRIDGE. A round iron bar used to hold the members of a bridge together and in place.

It is usually provided with a square head and with screw threads at the other end to receive a nut, but is sometimes pointed, with or without threads. The members of wooden bridges are held together



Round Bridge and Roof Bolt
The Oliver Iron & Steel Co.



Square Bridge and Roof Bolt
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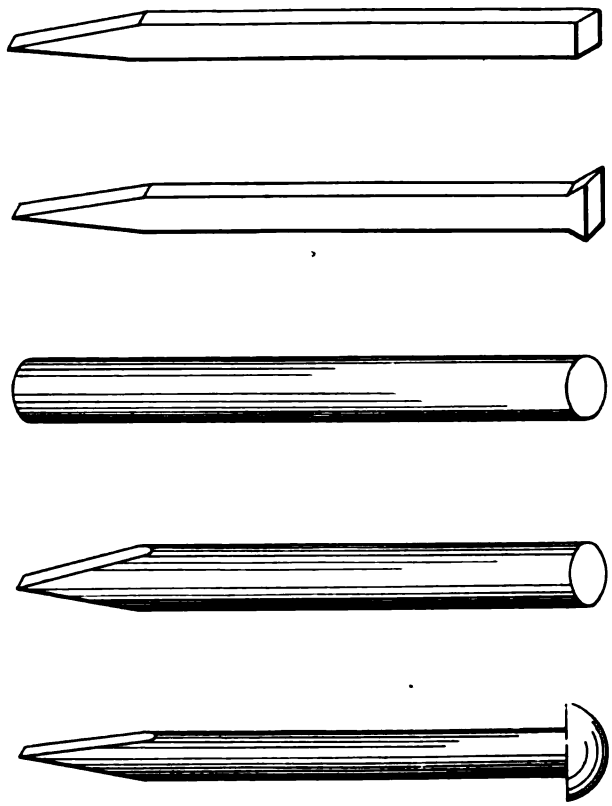
chiefly by threaded bolts with nuts and washers, though drift bolts or pins without threads are used to hold caps to piling, etc., and short bolts with screw nuts, known as fitting-up bolts are used temporarily in bridge erection until the rivets are driven in their places. The length of the threaded portion

Bridge Bolt with Upset Ends

of a bolt is usually 2½ times its diameter, the dimensions and character of the metal varying with the thickness of the material to be fastened together and the strain to be imposed. See Bridge.

BOLT, DRIFT. A rod of round or square metal with or without a head, usually pointed and driven as a spike.

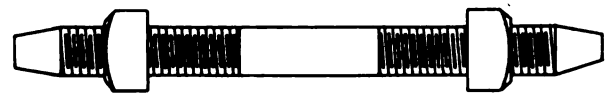


Drift Bolts

This type of bolt is commonly used in wooden bridges to hold caps to the piling of pile bents and the bottom sills to the pile foundations of trestle bents as well as to secure the caps and sills of bents to their upright members. It is usually made of wrought iron or steel, sometimes with a flattened or a square head and preferably with a chisel point to prevent tearing the wood fibre, and it is preferably driven in a bored hole of a diameter slightly less than that of the bolt. Drift bolts average about ¾ in. in diameter and vary from about 18 in. to 30 in. in length.

BOLT, FALSEWORK. Any bolt used temporarily to hold the members of a temporary structure or falsework together.

This type of bolt is designed to be used in temporary structures erected as a means of constructing permanent bridges. It is made with a single or a double nut. Single nut bolts are similar to the ordinary bridge bolt except that the shank and screw threads are commonly somewhat longer. Double

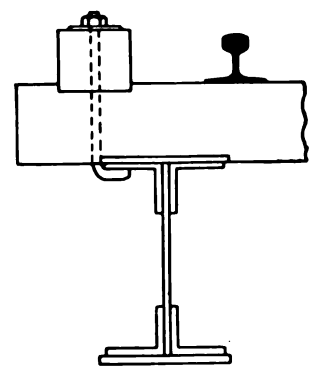


Falsework Bolt

nut bolts are bolts without heads, threaded to receive a nut at each end.

BOLT, FITTING UP. A threaded bolt used in the assembling of steel structures to hold bridge members, etc., temporarily together until it can be replaced by a rivet, or sometimes by a turned bolt. See Bolt, Turned.

BOLT, HOLDING DOWN. A bolt used to secure bridge members, etc., to their bases or footings. One end of the bolt usually is secured to the base while the threaded end protrudes vertically through a slot in the base plate to hold the nut which is screwed down over the plate to hold down the column or other member.



Hook Bolt Applied

BOLT, HOOK. A bolt with a hooked head designed to fasten wooden cross ties and bond timbers to the top flange of a bridge girder.

The hook end of the bolt is usually a short right angle bend which engages the under side of the flange while the upper straight end is provided with threads and a nut.

BOLT, SWAY BRACE. A headed and threaded bolt used with washers and a nut to hold the sway brace across the vertical members of a wooden pile or frame trestle bent.

Sway-brace bolts are commonly round wrought iron or steel rods designed to pass through the sway brace and the vertical member between, to hold the bent firmly in position and prevent side motion. They are usually provided with square heads and screw threads and blunt end threaded points. Bolts of this type average about ¾ in. in diameter and are generally from 16 in. to 24 in. in length.

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BOLT, TURNED. A threaded steel bridge bolt designed to serve permanently the purposes of a rivet.

With a view to transmitting stress the bolt is machine-turned to admit of a driving fit in a reamed hole through steel plates, etc., which are secured between the head and nut washers. The turned bolt is used in finished work as distinguished from the fitting-up or erection bolt which is of temporary use in structural fabrication or erection.

BOND TIMBER. One of two lines of longitudinal timbers placed on a bridge at either side of the track to maintain the spacing of the ties.

Frequently the bond timber, which is commonly 6 in. by 8 in. random length, is dapped from 6 in. to 4 in. thickness over each tie. It is placed close to the ends of the ties with the dapped side down and spiked or bolted, sometimes to all, but more commonly to every fourth tie and is frequently fastened down to the caps of the timber bents with long bolts. Lag screws are sometimes used to fasten the bond timber to each tie. The end joints of abutting bond timbers are usually butt or lap joints. Although this timber is sometimes called a wooden guard rail or a guard timber it is essentially a tie-bonding piece. It should not be depended on to prevent derailed wheels from leaving the bridge as it is too far from the running rail and too close to the edge of the deck to be as effective as the metal guard rail placed between the running rails for that purpose.

BRIDGE. A structure of metal, wood or masonry designed to afford a passageway over a waterway, a ravine or other natural or artificial depression without materially obstructing the area spanned.

Railway bridges include not only crossings over waterways, but structures to carry the tracks over or under streets, roads and other railways; also minor structures such as signal bridges, dock approaches, ferry aprons, stock passes, material storage bridges, overhead foot bridges, etc.

The availability of suitable materials, always a governing factor in bridge design, for many years restricted the railways to timber, to stone masonry and to an increasing percentage of iron, which was gradually superseded by steel during several years preceding 1890, while the use of mass concrete followed the perfection of methods of making Portland cement and generally replaced stone masonry construction when Portland cement of American manufacture became readily available and the advantage of using metal reinforcement was demonstrated mathematically.

Bridges may be classified as to materials of construction, as (1) metal bridges, (2) concrete bridges of reinforced or mass design and (3) timber bridges. From the standpoint of design the principal types of bridges are (1) the simple beam span, (2) the cantilever bridge, (3) the continuous girder bridge, (4) the arch and (5) the suspension bridge. A further distinction is made as between fixed bridges (which greatly predominate) and movable spans, a special type used only at crossings of railway tracks over navigable streams where there is not sufficient clearance for the water traffic under a fixed bridge. Movable spans may (1) swing horizontally, (2) lift by rotation from one end, (3) lift vertically by translation. A further distinction is made on the basis of the angle of crossings, a 90 deg. crossing being known as square while a structure at any other angle is called a skew bridge. Still another distinction is made to designate the positions and characteristics of bridge floors, a structure being known as (1) a deck bridge, in which the floor system rests on the tops of the main supporting structures; (2) a through bridge in which the floor system is placed between the main trusses or girders; or (3) a double deck bridge, which has two floors, one on and another between the main members. As to other characteristics, the bridge floor may be (1) open or (2) solid. Open bridge floors are of two types, (1) the beam and stringer type and (2) the transverse I-beam type. Solid floors may be (1) ballasted or (2) without ballast. Ballast floors are in use on many steel, concrete and timber bridges. In addition to the advantage of placing the track on ballast they minimize the fire hazard especially on timber structures. Ballast floors of wood are sometimes used on steel structures. All material for wooden ballast decks is preferably treated with a preservative with a view to overcoming the greater tendency to decay in such structures.

While ballast floors of steel bridges were formerly made of flat or convexly bent steel plates, covering the floor system, they are now usually made of reinforced concrete slabs upturned at the sides to retain the ballast. Sometimes the floor consists of a series of lateral steel troughs between alternate raised sections, waterproofed, filled with concrete and covered to the desired depth with ballast; or if a shallow deck is imperative, the troughs may be almost filled with ballast, and a tie laid in each one, the bottom of the tie being an inch or more below the top of the trough.

Reinforced concrete slabs poured in place or precast are extensively used for ballast floors, the slabs taking the place of the entire deck of the bridge. In some cases one slab is designed to cover the whole floor area of a span or it may be divided into two slabs along the center line of the bridge.

As to materials, metal bridges usually are made of fabricated carbon steel although in some cases nickel-steel or a similar alloy is used, while masonry structures, usually of concrete, are sometimes made of stone or brick. To minimize the amount of masonry necessary, and to make the use of slabs and girders possible, bridge members are now generally reinforced with steel embedded in the concrete. Timber bridges, although frequently made of untreated timber, are preferably constructed of members chemically treated with a wood preservative to prolong their service life.

Steel bridges are of various designs and are in general use for extensive permanent structures, especially where the spans are long or the supports are high. The principal types are (1) the truss, (a) riveted, (b) pin-connected, (2) the girder; (3) the viaduct, which may include either truss or girder spans or both; (4) the arch, which may be (a) single ribbed, (b) double ribbed, or (c) spandrel braced; (5) the beam or longitudinal trough bridge, either of which may be of (a) all-steel construction or (b) steel encased in concrete.

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Masonry bridges, including (1) concrete, (a) which may be plain concrete or (b) concrete reinforced with steel rods, etc. (2) stone; and (3) brick, are usually made of (1) truss, (2) girder, (3) arch or (4) slab design. The trusses as in steel bridges are of many designs and various systems of bracing; the girder bridges may have either deck or through spans; stone or brick arches are usually limited to the filled spandrel type; reinforced concrete arch bridges are built in filled and open spandrel designs with solid ring or ribs as well as in the suspended floor type.

Masonry (concrete) trestle bridges are reinforced concrete structures, the trestle supports being either solid piers or bents of concrete piling supporting reinforced concrete caps, on which the longitudinal girders or slabs are laid. The slabs may be one-way, two-way or flat, while all the bridge members may be either pre-cast or built in place.

Timber is used for two designs of bridges, (1) trusses and (2) trestle bridges. Although several designs of wooden trusses were formerly made, the Howe truss is the only form now in general use. Timber trestle bridges are known by their forms of support, which are (a) pile bents and (b) framed timber bents. The decks of either type may have open or solid ballasted floors.

Bridges of short spans, while of less individual importance than those of long spans and great extent, are so much more numerous that their designs are usually standardized by a railway for the various lengths most frequently needed. Some of these types are open top deck girder bridges for openings 15 ft. wide or even less, although such waterways are commonly carried through culverts. There is in fact no clear line of demarcation between one-span bridges and large culverts.

Some railways limit culverts to a certain maximum span, above which all spans are called bridges; on other lines a culvert is considered as an opening through an embankment, the top of the culvert being below subgrade while a bridge is distinguished as a structure which has no embankment over it. These and other distinctions are however more or less arbitrary. Culverts are made in the forms of (1) arches, (2) boxes and (3) pipes. The materials of construction are (1) masonry, which may be of (a) reinforced concrete, (b) plain concrete, (c) stone with or without mortar, (d) brick; (2) cast iron pipe, (3) sheet iron pipe, black or galvanized, (4) pure iron pipe, black or galvanized, (5) earthenware pipe, and (6) wood. A distinction is commonly made between (1) culverts built in place, as arch and box culverts are made, (2) culverts made of pre-cast pipes, and (3) culverts built in place except the tops which are of pre-cast slabs of reinforced concrete, or slabs of quarried stone. A further classification is based on the number of spans or lines of pipe which may be (1) single span (2) double span or (3) multiple span. The minimum culvert commonly used is a pipe 24 in. in diameter, a box 24 in. square or an arch of equal cross sectional area. Smaller tubes or boxes are commonly called drains and are preferably not used under railway embankments because of the difficulty of clearing them of obstructions.

Metal Bridges

Steel is the only metal of which bridges are now made. Alloy steel is used in members of some exceptionally long spans, but carbon steel is the metal of general utility, employed in the construction of both fixed and movable bridges. The selected type of structure is designed for the necessary loading and the fabrication of the steel is done from shop drawings and templates to insure accuracy, as little riveting as possible being left to be done in the field, for the riveting can be done better with shop pressure machines and under the conditions at the bridge shop than with portable percussion tools in the field during the bridge erection. The members made in the shops are assembled in maximum units for shipment usually by rail. Before leaving the shop, the steel work is painted one coat, usually red lead and oil to prevent rusting, each member being lettered and numbered to identify its position in the structure. The finished steel work is shipped in car load lots, the small parts, the rivets, bolts, washers, etc., in boxes. It is erected usually on falsework in such a way that the existing bridge may be used until it has been fully replaced by the new one with practically no interruption of traffic. The problems of erection, involving the minimum labor and use of falsework and the quick handling of steel work to avoid traffic delays, include usually the employment of special erection derrick cars or locomotive cranes and a corps of expert steel workers and riveters under competent supervision, for unforeseen obstacles frequently have to be met and overcome in the field. As soon as rivets are driven in the field they are patch-painted to prevent rust and when the bridge is erected it is thoroughly covered with preservative paint. The life of a metal bridge depends largely on the loading. If in good condition it will bear overloading for a period, but overloads tend to increase any movement among parts, to reduce the efficiency and safety and to shorten the life of the bridge. Many structures become obsolete long before the metal deteriorates because increasing train loads demand stronger bridges. Deterioration results from motion among the parts, from rust and from oxidation by the weather, from locomotive smoke, brine drippings from cars, acids from chemical plants, etc. It is good practice to provide smoke guards under bridges over railway tracks especially where the overhead clearance is scant, so that the exhaust from locomotive stacks may be deflected from the bridge structure. The maintenance and inspection of metal bridges includes the frequent periodical testing of line, surface, camber and deflection, any variation in line or surface being an indication of possible settlement in the foundation, while reduced camber and increased deflection show weakness of the suspended structure; the testing of rivets and observation of devices for contraction and expansion, and of any evidence of movement among the members which indicates unequal loading, as well as signs of deterioration, etc. The simplest form of metal bridge is made of rolled beams supported only at the two ends, such as I-beams. Such structures consist commonly of a number of beams laid in parallel lines or equally spaced over the piers of a span and connected by means of riveted steel plates and angles or encased in concrete. Such

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spans are frequently placed over stock passes, farm roads, waterways, etc.

Girder Bridges

Girders are used commonly for spans of 30 ft. to 100 ft. and sometimes up to 125 ft. long. A girder span consists usually of a pair of parallel girders with suitable connections to hold them together in their correct relative positions and to lend stiffness to the structure as a whole. Deck girder bridges are preferable to through girders on account of the unrestricted side clearance afforded by placing the deck on the top flanges, as well as the comparative economy of this style of deck over the more elaborate floor system necessitated to carry the track between the widely spread through girders. This floor system has the advantage of being entirely above the bottom flanges of the through girders below which the space is clear, but the width is 16 ft. or more between girders, which necessitates a considerable tonnage of steel in the floor system and a width of supporting substructure not required in the deck type. Through girder bridges are utilized especially with a view to obtaining the greatest possible vertical clearance below the structure. The top flanges of a girder being normally in compression tend to buckle under load and are therefore stiffened by lateral bracing wherever possible. In a through girder this cannot be done and as a substitute this design is commonly provided with triangular bracket braces called gusset plates, one of which is backed against the main girder at each end of a floor beam, the base being riveted to the floor beam and the longer vertical back to the girder to hold it upright. All through girders and the longer deck girders are provided with lateral bracing in the plane of the bottom flanges. Vertical stiffener angles are riveted from flange to flange at suitable intervals to keep the web plate from buckling and cover plates are frequently riveted on the flanges to reinforce them. The ends of the top flanges may be either horizontal or in through girders bent down to meet the bottom flange, thus forming a rounded end that serves as a protection against objects which strike it.

Girder bridges are economical structures for spans from 30 ft. to 100 ft. in length, center to center of end bearings. The lengths of girders are roughly 9 times their depths.

Bridges of the truss types (1) deck and (2) through trusses were first made of wood, later of iron and more recently of steel, although the Howe truss, formerly designed in iron as well as timber, is now the only timber truss in general use, other types being now made almost exclusively of steel, riveted or pin connected. Riveted trusses are now in common use in America for spans of 100 ft. and upwards, following the European practice, the Pennsylvania R. R. bridge over the Ohio River at Louisville, Ky., having a simple riveted span of high carbon steel 645 ft. long.

The pin connected truss is essentially an American type, used especially for long spans, the Chicago, Burlington & Quincy R. R. structure over the Ohio River at Metropolis, Ill., including a span 720 ft. in length, the longest simple truss span in the world.

Pony trusses consist of low truss members without top lateral bracing, comparable to the through girder. Such types are used on some roads for spans of 100 ft. to 150 ft. or thereabouts. A disadvantage of the type is the absence of top bracing.

The types of truss well known in American practice include (1) Fink, (2) Bollman, (3) Whipple, (4) Howe, (5) Pratt, (6) Warren, (7) Baltimore, (8) Post, (9) Bowstring, (10) Parker and (11) Pennsylvania. The Fink truss is now rarely used for railway bridges, but several such structures have been erected on one line in recent years. The design is generally considered not so desirable as others in common use. Post, Bollman and Whipple trusses are no longer built. The various types differ chiefly in the styles of framing, excepting the last three, which have inclined top chords, some bow string spans being known as parabolic because of the relative positions of the top panel points.

The depths of trusses in ratio to their lengths vary from 1 in 5 for short spans to 1 in 8 or even 1 in 9 for the longest spans, the economic depth being that which minimizes the material for the desired stiffness and necessary loading, depening on the length and number of panels, the form of truss and the unit stress allowable.

Pin connected trusses, used in America for spans of all lengths until about 1890, have been superseded largely by riveted designs for spans up to about 200 ft. in length due to the greater stiffness afforded and because of the vibration of the individual members. The pin-connected truss is usually lighter and more easily erected than the riveted types, the eye bars being readily assembled and threaded on the pins while the built up members of the riveted truss must be assembled temporarily with fitting up bolts after which the connections are riveted.

Trusses are usually cambered from 0.001 to 0.002 of the length of the span in order that under the deflection due to the maximum load, the structure will take the form assumed in the design. Deflection may be due to elastic deformation under load, to changes in temperature, etc., or to play in the connections.

The bracing systems of through trusses consist of horizontal trusses in the planes of the top and bottom chords and transverse diagonal bracing at the top panel points called sway bracing, which extends down as far as the vertical clearances will allow, the end sway bracing being always in the plane of the end posts whether vertical or inclined. Deck bridges have top laterals and usually bottom laterals as well as vertical transverse systems of bracing at panel points. The floor beams are utilized as struts of the top lateral system while the chords of the main trusses serve also as chords of both lateral systems. The sway bracing at the ends of the bridge is always heavier than at intermediate panel points.

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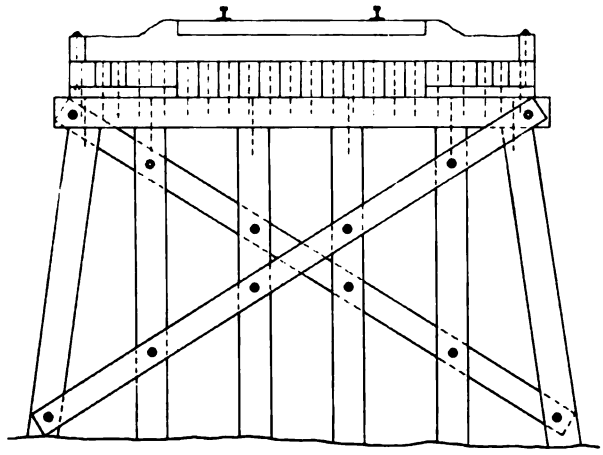
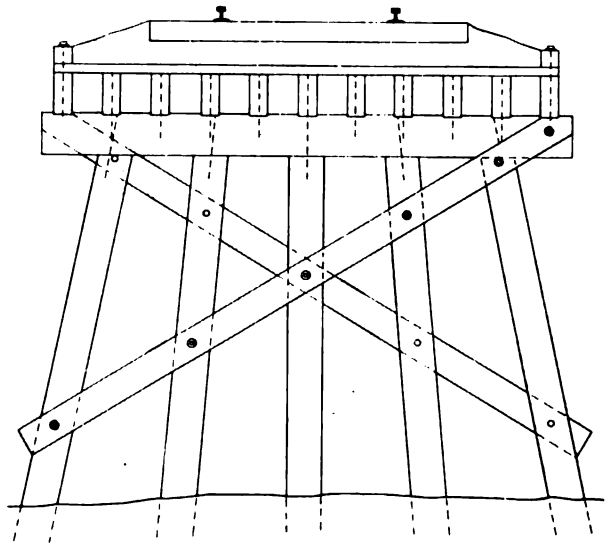
BRIDGE, BALLAST FLOOR. A bridge with a solid floor on which the ballast and track structure are placed so as to reproduce as nearly as possible the track conditions on an earth roadbed. See Bridge.



Ballast Deck Wood Trestle Bridge



Ballast Deck Wood Trestle Bridge

Concrete Slab Floor Bridge for Street Subway

Concrete Slab Floor Bridge

BRIDGE, BASCULE. Any movable bridge which is moved in a vertical plane, rotating about a horizontal axis or rolling back from the opening as it lifts. This type of structure is used especially where the space and time for operation are restricted.

Of the various designs of bascule bridges the counter-weighted through truss is the common type although deck trusses and sometimes girder spans are also used. A bascule bridge may be of the single or double leaf type, the free ends of the double leaf bridge meeting in the center when closed, where they are held by automatic locking devices on the upper and lower chords; while the free end of a single leaf bascule is locked down on the rest pier when closed.

The term trunnion bascule is used to denote those spans which rotate about trunnions or short shafts. The counterweight is usually a heavy block of concrete hinged or linked overhead or sometimes under the deck to the short arm of the structure which extends back of the fixed support as a lever, operating on the trunnions or other fulcrum device to balance the moving arm which spans the waterway. The arrangement of the counterweight and its supporting structure must be such that the span is balanced in all positions. The span is opened and closed by means of a rack and pinion drive.

The rolling lift bascule does not rotate on trunnions but rolls backward on the counterweighted end of the girder which is curved to travel on a horizontal track and pinion device, the leaf rising as it moves away from the opening. The counterweight of the rolling lift girder is usually placed overhead at the upper end of the arc at the heel of the span. While a bascule bridge may be operated by any reliable power it is considered good practice to have main and auxiliary power plants, to insure continuous operation in cases of emergency. Electrical power is more suitable than steam because of the readiness with which it may be transmitted and cut off, the compactness of the plant, the reliability of current (especially in hydro-electrical plants) as compared with coal supplies for steam power and the instantaneous action

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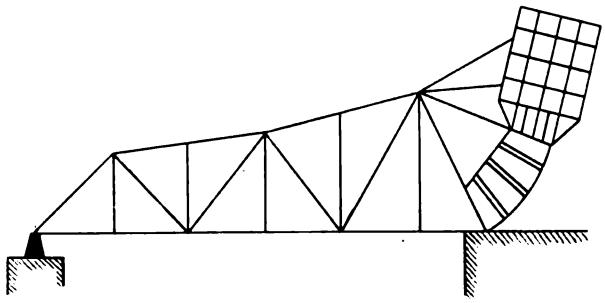
obtainable in operation. Gas engine auxiliary power plants are frequently installed, and sometimes the storage battery system is employed as the main



Sketch of a Rolling Lift Bridge

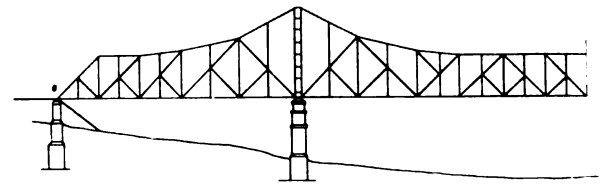
power plant in preference to steam, thereby eliminating the necessity of continuously firing a boiler.

The electrical operating mechanism is commonly placed in a tower so situated as to afford the attendant the best view of the traffic beneath as well as on the structure, unless it is situated within the limits of an interlocking plant, in which case the operation may be under the control of the plant operator. The mechanism of a bascule span and the operating machinery require the attention of skilled mechanics. It is considered good practice to place a reliable mechanician who has intimate practical knowledge of electrical plants in responsible charge with authority over the bridge tenders, who should be mechanics. Such a force is usually able to keep a busy bascule span in running order, arranging to make the more extensive repairs, such as replacing brake shoes and rail locks, during the closed seasons of navigation. See Bridge.

Three-Track, Single-Leaf, Heel-Trunnion Type Bascule Bridge

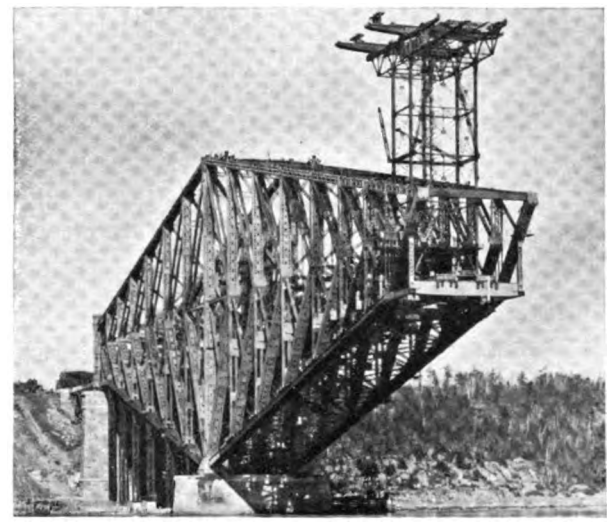
BRIDGE, CANTILEVER. A bridge usually consisting of trusses, two of which are built over centralized piers and counterweighted or anchored at the shore ends to support a middle span between their outer ends.

The cantilever principle is frequently used in bridge erection, where the finished structure is of



Sketch of a Cantilever Span

some other design as a simple span or arch. The principle advantage of the cantilever bridge and system of erection is that the structure may be built from the piers outward across a channel without the necessity for falsework. The cantilever truss is balanced during erection on its central pier until



Complete Cantilever Arm of Quebec Bridge

the construction reaches the anchorage at the shore end, or it is counter-weighted to balance the weight at the outer end. Extensive cantilever bridges are commonly anchored at the shore ends while the central truss is held between the outer ends. See Bridge.

BRIDGE, FIXED. Any bridge which is designed to be immovable on its foundations as distinguished from structures which have movable spans designed to be revolved or lifted to permit passage of vessels. See Bridge. Also Bridge, Movable.

BRIDGE FLOOR. That portion of a bridge designed to support the track structure directly.

Bridge floors may be classified as (1) open and (2) solid. An open floor consists of beams which may be variously arranged to support the rails, or the rails and ties, without provision for enclosing

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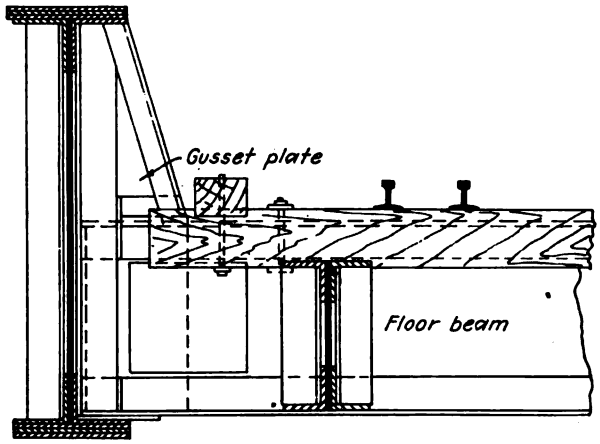
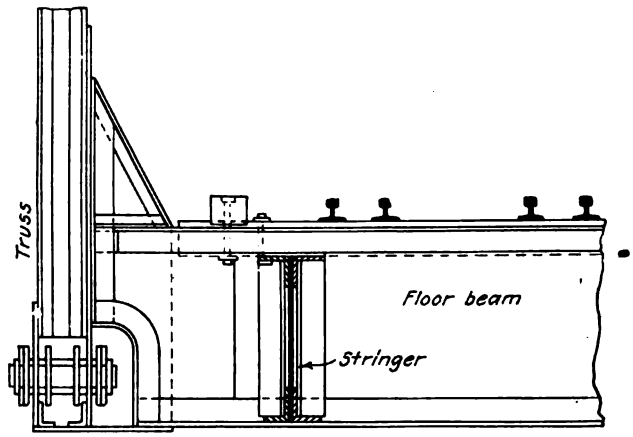
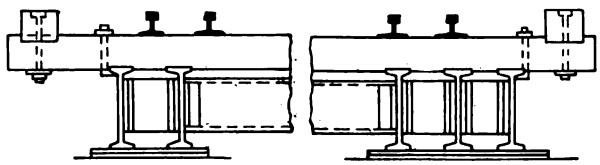


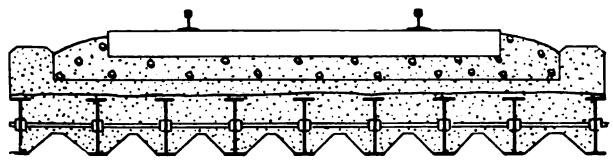
Open Floor Through Girder Bridge, Floor Beam and Stringer Type



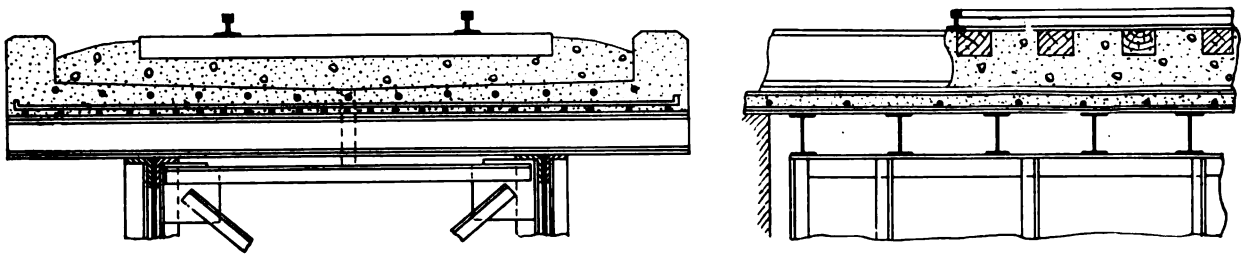
Open Floor Through Truss Bridge, Floor Beam and Stringer Type



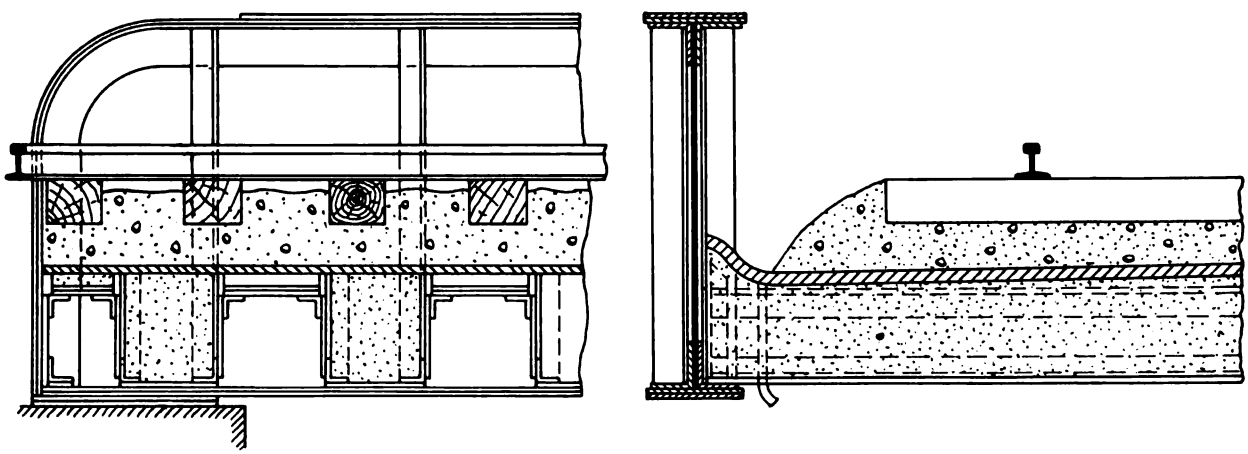
Open Floor I-Beam Bridge



Solid Floor of Encased Longitudinal I-Beams



Solid Floor, Concrete Slab Supported by Transverse I-Beams on Deck Girders



Solid Floor, Transverse Steel Troughs Filled with Concrete

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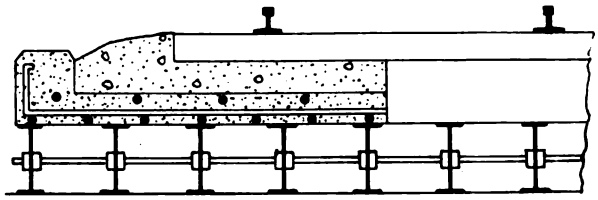
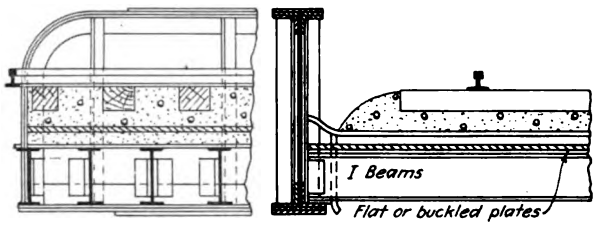
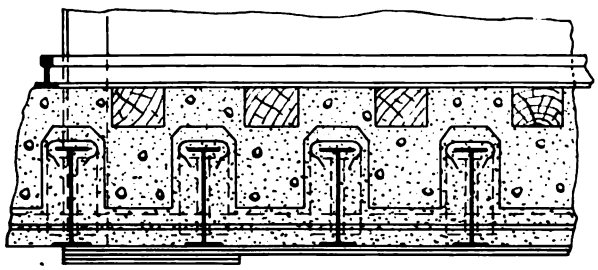


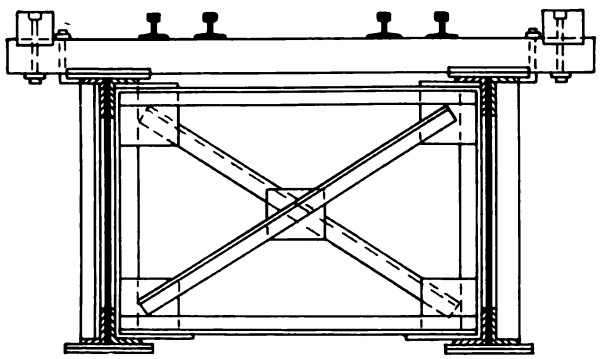
Solid Floor, Longitudinal I-Beams and Slab



Solid Floor Bridge with Transverse I-Beams in Through Girders



Solid Floor Bridge of the Encased Transverse I-Beam Type

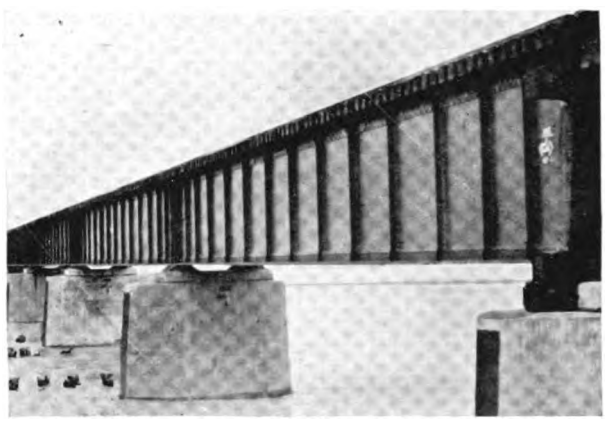


Open Floor Deck Plate Girder Span

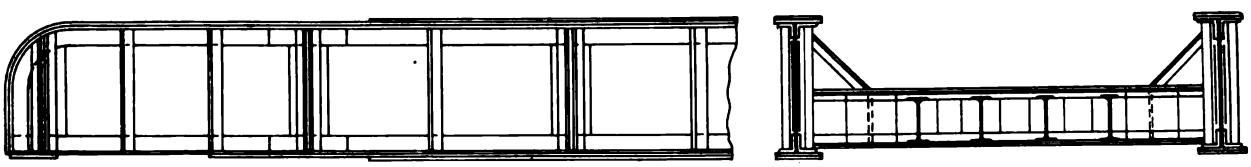
the open spaces between; as distinguished from a solid floor which affords an unbroken surface on which the ballast may be laid. Open floor timber trestle bridges have parallel, longitudinal stringer chords across which the track ties are laid. In open floor steel deck bridges, the track ties usually are similarly laid across and bear directly on the top flanges of the girders or trusses, while in through bridges the open floor system consists commonly of transverse floor beams between or on which longitudinal steel beams are secured and suitably spaced to support the ties directly.

Solid bridge floors are made of timber stringers placed parallel with the track and edge to edge, or with narrow spaces between them. In the latter case, a tight plank floor is laid across the stringers. In either case the floor is preferably treated with a wood preservative and ballasted track is laid on it. Metal sheets or trough-shaped beams, either placed parallel with or at right angles to the track are also used as solid bridge floors, usually for ballasted track. Reinforced concrete slabs constitute the floor system of many concrete trestle bridges, where two slabs placed side by side commonly occupy the entire floor space of a span, although various arrangements of concrete bridge floors are in use, the concrete being precast or poured in place. See Bridge. Also Bridge, Ballast Floor.

BRIDGE, GIRDER. A steel bridge in which the track is supported on the tops of or between two or more horizontal girders which span the space between upright bents or other substructures, the type with the track on top being known as a deck girder



Deck Plate Girders on Concrete Piers



Double Track Through Girder Span

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Deck Girder Span on Stone Masonry Abutments

bridge and that with the track between the girders being called a through girder bridge. See Bridge.

BRIDGE GUARD. See Bridge Warning.

BRIDGE GUARD RAIL. A line of special rails laid parallel to and between the running rails of a track over a bridge and its approaches to keep derailed wheels close to the running rails. See Bond Timber.

BRIDGE, I-BEAM. A type of steel railway bridge consisting essentially of a number of rolled steel I-beams used as stringers, laid parallel to one another extending between the adjacent piers or abutments to support the floor system.

Two or more I-beams are commonly laid longitudinally side by side under each running rail, their ends resting on the abutments or other supports of the span which usually is 30 ft. or less in length. The top and bottom flanges of standard I-beams are identical, while their widths are less than the height of the beam, commonly one-sixth the depth plus three inches. The I-beams commonly used in bridges are from 6 in. to 15 in. high and less than 20 ft. in length. At each end and at the center of the span, a cross frame is riveted between the opposite I-beams while at intervals of about 5 ft. channel separators are placed between the beams to brace them transversely and to obtain the strength of unity of the parts which form the stringer chords. The chords are preferably so placed that the track rail is centered above the middle beam of a three-beam stringer or between the pairs of a four-beam stringer. I-beam bridges are commonly used over small streams where scant vertical clearance demands shallow decks, or in grade separation work or stock passes. See Beam. Also Bridge.

BRIDGE INSPECTION. The observance of the various steps in (1) the manufacture of materials for bridges in the mill, (2) of the fabrication of bridge members from the materials in the shop, (3) of the assembly of the parts and the erection of the bridge structure on its foundations and (4) the periodical examination of the completed bridge under traffic.

The A. R. E. A. has adopted the following rules and instructions in regard to these details:

Instructions for the Mill Inspection of Structural Steel

1. Study the contract and specifications and secure such information concerning the proposed structure as will permit a full understanding of the use to be made of the various items of the order.
2. Secure copies of the mill orders, shipping directions and other information concerning the material to be inspected.
3. Attend promptly when notified of the rolling of material and so conduct the inspection and tests as not to interfere unnecessarily with the operations of the mill.
4. Have the test specimens prepared and properly stamped with the melt numbers by the manufacturer. Observe the selection and stamping of specimens and verify the melt numbers when practicable.
5. Attend and supervise the making of tensile, bending and drifting tests. Make sure that the testing machines are properly handled and that the specified speed of pulling is not exceeded. Note the behavior of the metal and check and record the results of the tests.
6. Select the bars or other members for full-size tests as specified. Supervise such tests and check and record their results.
7. Secure from the manufacturer records of the chemical analyses of the melts and accept only those in which the specified contents of impurities are not exceeded.
8. Secure pieces of the test ingots and test specimens and have check analyses made outside of the manufacturers' laboratory when the analyses furnished by the manufacturer are erratic or for any other reason appear to be incorrect.
9. Examine each piece of finished material for surface defects before shipment, requiring the material to be handled in a manner that will permit the examination to be thorough and complete. This inspection should detect evidence of excessive gagging or other injury due to cold straightening.
10. Report promptly the shipment of any material from the mill, whose surface inspection has been waived. Such material should be examined by the shop inspector.
11. Verify the section of all material by measurements and by weight.
12. Study the operations of the plant and become familiar with the various processes of manufacture.

Cultivate the acquaintance of the mill employees and become familiar with their work so as to have direct knowledge of the mill practice and determine as well as the circumstances permit the correctness of the mill practice in so far as it is covered by the specifications.

13. Record all tests and analyses on the forms provided.
14. Keep informed as to the progress of the work in the shop and endeavor to secure the shipment of material at such times and in such order as to avoid delay in the fabrication.
15. Secure copies of the shipping lists and compare them with the orders and make regular statements of the material that has been rolled and shipped.
16. Make reports weekly or as may be directed, submitting complete records of tests, analyses and shipments and such other information as may be required.

Instructions for the Inspection of the Fabrication of Steel Bridges

1. Acquire a full knowledge of the conditions of the contract, such as the time of delivery, the railway company's actual need of the work, the desired order of shipment, and any special features in connection with the delivery, such as the position of the girders or truss members on cars at the bridge site.
2. Study in advance the plants and specifications and see that all provisions thereof are complied with. These instructions are not to be construed as altering the specifications in any way.
3. Endeavor to maintain pleasant relations with foremen and workmen; and by fairness, decisiveness and good sense, interest them in the successful completion of the work.
4. Attend constantly to the work, making inspection during the progress of the work in the shop, striving to keep up with the output in order that errors may be corrected before the work leaves the shop.

Conduct the inspection so as not to interfere unnecessarily with the routine operations of the shop.

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5. When unusual circumstances require an explanation of the plans or some variation from the specified procedure, take the necessary action promptly.

6. Study the field connections, paying particular attention to clearances and making notations on the drawings so that they may be checked rapidly.

7. Check all levels and field rivet holes.

8. Give careful attention to the quality of the workmanship, the condition of the plain material, accuracy of punching, care in assembling, alinement of rivets, tightness of rivets, accuracy of finishing of machined joints, painting and general finish.

9. Make sure that reamed holes are truly cylindrical and that drillings are not allowed to remain between assembled parts.

10. Watch for bends, kinks and twists in the finished members and make certain that when leaving the shop members are in proper condition for erection.

11. Make sure that the webs of girders do not project beyond the flange angles and that the depth of web below the flange angles complies with the specification.

12. Allow only the material rolled and accepted for the work to be used therein.

13. Have the fabricated material shipped in the correct order for erection and in accordance with instructions, as far as practicable.

14. Measure the width of each column and the lengths of all girders between columns when they are to be placed consecutively in a long row so as to insure that the columns and girders will not "build out" in erection so as to exceed the calculated length.

15. Check "rights" and "lefts" and make sure that the proper number of each is shipped.

16. Check base plates of girders before riveting and make sure that the bevel is not reversed.

17. Check the space provided for driving field rivets, allowing sufficient space for the pneumatic riveter.

18. Examine field connections after riveting to insure proper fitting and ease of erection.

19. Make sure that shop splices are properly fitted and that matched and milled surfaces to transmit bearing are in close contact during riveting as specified.

20. Examine and measure bored pinholes carefully to insure proper position, dimension, spacing and smoothness of finish.

21. Measure the spacing center to center of the end connections for sections of I-beam floors or any similar construction in which the calculated spacing is liable to be exceeded because of the tendency of such work to "grow" as it is assembled.

22. Make sure that stringers connecting to floor beams beneath the flange have sufficient clearance to care for their possible over-run in depth.

23. Have the assembling of trusses and girder spans required by the specifications carefully done and in any case insure the accuracy of field connections. If a large number of duplicate parts are to be made, the number of parts to be assembled should be governed by the workmanship. If errors are found, a sufficient number of parts should be assembled to make it reasonably certain that such errors have been eliminated.

24. Secure match-marking diagrams for work which has been assembled and reamed and make sure that the match marks are plainly visible.

25. Have proper camber blocking used in assembling trusses and secure the desired camber before the reaming is done.

26. Require that all treads and supports for the drums of draw spans be carefully leveled with an instrument.

27. Study carefully the machine details and discriminate between those dimensions which must be exact and those in which slight variations are permissible.

Determine in advance the desired accuracy of fits for bolts or keys and similar parts and make sure that such accuracy is attained.

28. Examine castings carefully for blowholes and other imperfections and discriminate between such defects as are unimportant and those which render the castings unfit for use.

29. Make sure that bushings, collars and similar parts are held securely in place.

30. Make sure that all drum wheels, expansion rollers, turntable rollers and similar parts are exact in size, so as to carry equally the loads which may be placed upon them.

31. Ascertain in advance that the paint provided complies with specifications. Watch carefully the painting directions and make sure that paint is properly applied and only where intended.

32. Verify all shop marks and make sure that they are legible as well as correct.

33. Have important members so loaded as to be headed in the right direction upon arrival at the site of the work.

34. Try a few countersunk head bolts in the holes where they are to be used to insure a proper fit.

35. Make sure that small pieces are bolted in place for shipment as shown on the plants and that other small parts are properly boxed or otherwise secured against loss.

36. Make sure that rivets, tie rods, anchor bolts and miscellaneous parts are shipped so as to avoid delay in erection.

37. Examine the field rivets to insure that they are free from fins or other defects.

38. Exercise special care in the examination of all movable structures and particularly their moving parts.

39. Make reports weekly or as directed, exhibiting carefully and concisely the actual conditions.

40. Observe carefully and report such unusual difficulties as may be encountered and the means adopted in overcoming them and endeavor by a study of the details or other means to make recommendations which will prevent their recurrence in future work.

41. Check every finished member against the drawings for its general dimensions and for the section of each piece of material forming a component part of the number.

42. Attend the weighing of material whenever practicable, especially that purchased on weight basis. Check the accuracy of the scales with test weights or by other sufficient means.

Instructions for the Inspection of Bridge Erection

1. Study and observe the plans and specifications for steel construction. Study the masonry plans and check the masonry as built with the steel plans.

2. Familiarize yourself with the local conditions affecting erection.

Make the acquaintance of the principal men engaged upon the work and of local residents whose interests may be affected thereby.

3. Obtain and study carefully the employees timetable and be well posted concerning the time and relative importance of regular and extra trains. Acquaint yourself with all special traffic arrangements made because of the work in hand.

4. Secure full information concerning the conditions of the work in the bridge shop and the probable dates of shipment.

5. Obtain reports of any uncompleted or erroneous work that must be attended to after arrival of the material in the field.

6. Study the erection program in order to avoid delays and be able to recommend some other procedure in an emergency.

7. Endeavor to have full preparations made before disturbing the track so that the erection may proceed rapidly and the period of such disturbance be made a minimum.

8. Keep a record of the arrival of all materials. The contractor's record should be sufficient if available. Strive to anticipate any shortage of material and use all available facilities to hasten delivery of the needed parts.

9. Study the progress of the work and determine whether it is likely to be completed in the time allotted. If not, endeavor to secure such additions to the force and equipment as will insure such completion.

10. Make a daily record of the force employed and the distribution of labor, in a way that will assist in following paragraphs 9 and 23.

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11. Exercise a constant supervision of any temporary structure or falsework and make soundings if necessary with the purpose of discovering any evidence of failure or lack of safety and having it corrected before damage is done. Examine erection equipment with a view to its safety and adequacy.

12. Be constantly on hand when work is in progress and note any damage to the metal, failure to conform to the specifications, or any especial difficulty in assembling.

13. Make sure that each member of the structure is placed in its proper position. If match marks are used, examine them with care.

Endeavor to have the several members assembled in such order that no unsatisfactory makeshifts need be resorted to in getting some minor member in place.

14. Prevent any abuse or rough usage of the material. Bending, straining and heavy pounding with sledges are included in such abuse.

15. Watch carefully the use of fillers, washers and threaded members to see that they are neither omitted nor misused.

16. Make certain that all parts of the structure are properly alined and that the required camber exists before riveting. It is possible for a structure to be badly distorted, although the rivet holes are well filled with bolts.

17. Watch the heating of rivets to prevent underheating or overheating and to make sure that scale is removed.

Examine and test carefully all field-driven rivets and have any that are loose or imperfect replaced.

Have cut out and replaced all rivets, whether shop-driven or field-driven, that may be loosened during erection and riveting.

Prevent injury to metal while removing rivets.

18. Present to the contractor at once for his attention any violation of the specifications or contract, and secure a correction or refer the matter to the proper authorities as soon as possible.

19. Keep informed concerning the use of company material and work trains and assist in procuring such material and trains when needed, and preserve a record thereof.

20. Secure a match-marking diagram of any old structure to be removed which it is desired to re-erect and see that each part of such structure is properly marked in accordance therewith. Make a record of the manner of cutting the old structure apart and report any damage to the members of the old structure. Indicate by sketches or otherwise such repairs or replacements as will be found necessary in re-erection.

21. Secure photographic records of progress and the important features of the work wherever practicable.

22. Make a record of all flagging of trains, whether performed for the benefit of the contractor or otherwise, delay to trains, personal injuries and accidents of every kind

23. Make reports as directed, showing the progress of the work, the size of the force and the equipment in use.

Make a final report showing the cost of labor of erection per ton of material erected, the cost of labor per rivet in riveting, the cost of correcting errors in design and fabrication and commenting on the design and details; and give such other information as may be useful in planning similar work.

Inspection of Bridges and Records of Inspection

1. Inspection by the regular section forces, daily, or as often as they inspect the track under their supervision. The object of this inspection is to discover any damage to the structure from fire, flood, derailments or other accidents from traffic, or any displacement in the structure in whole or in part. This inspection, due to the lack of skill on the part of the section forces, must necessarily be superficial, and will rarely, if ever, do more than call attention to unsafe conditions arising from causes other than those of natural depreciation. No reports of such inspections need be made unless adverse conditions are discovered.

2. At periodic intervals of from one to six months there should be inspections by bridge foremen and others experienced in bridge repairs. These inspections should be more thorough than those of the section forces, and are intended to discover all the defects, arising from traffic, to which the bridge is subjected, and those due to natural depreciation or other causes. Reports of such inspections should be made to the one next in authority; preferably to the one most directly or primarily responsible for the safety of the structures.

3. Annual or semi-annual inspections are to be made by men experienced in the design and maintenance of bridges; preferably by those who are primarily responsible for their safe maintenance. The reports of these inspections should be filed, and in connection with an examination of office data will determine the safety of the structures, and be the basis for decisions as to repairs, reinforcements or renewals.

BRIDGE, METAL. A bridge consisting of members built of rolled steel shapes combined to form a structure. See Bridge.

A. R. E. A. General Specifications for Steel Railway Bridges

Of Fixed Spans Less than 300 ft. in Length.

1920

PROPOSALS AND DRAWINGS.

1. **Definitions of Terms.** The term "Engineer" refers to the chief engineer of the company or his subordinates in authority. The term "Inspector" refers to the inspector or inspectors representing the company. The term "Company" refers to the railway company or railroad company party to the contract. The term "Contractor" refers to the manufacturing or fabricating contractor party to the contract.

2. **Proposals.** Bidders shall submit proposals to conform with the terms in the letter of invitation. The proposals preferably shall be based upon plans and specifications furnished by the company showing the general dimensions necessary for designing the structure, the stresses and the general or typical details. Invitations covering work to be designed or erected by the contractor shall state the general conditions at the site, such as track spacing, character of foundations, old structures, traffic conditions, etc.

3. **Drawings to Govern.** Where the drawings and the specifications differ, the drawings shall govern.

4. **Patented Devices.** The contractor shall protect the company against claims on account of patented devices or parts proposed by him.

5. **Drawings.** After the contract has been awarded and before any work is commenced, the contractor shall submit to the engineer for approval duplicate prints of stress sheets and shop drawings, unless such drawings shall have been prepared by the company. The tracings of these drawings shall be the property of and be delivered to the company after the completion of the contract. Shop drawings shall be made on the dull side of the tracing cloth, 24 by 36 in. in size, including margins. The margin at the left end shall be 1½ in. wide, and the others ½ in. wide. The title shall be in the lower right-hand corner. No changes shall be made on any approved drawing without the consent, in writing, of the engineer.

6. **Proposals and Drawings.** The contractor shall be responsible for the correctness of his drawings, and for shop fits and field connections, although the drawings may have been approved by the engineer.

7. Any material ordered by the contractor prior to the approval of the drawings shall be at his risk.

General Features of Design

8. **Materials Used.** Structures shall be made wholly of structural steel except where otherwise specified. Cast steel preferably shall be used for shoes and bearings. Cast iron may be used only where specifically authorized by the engineer.

9. **Types of Bridges.** The different types of bridges may be used as follows:

Rolled beams for spans up to 35 ft.

Plate girders for spans from 30 ft. to 125 ft.

Riveted trusses for spans from 100 ft. to 300 ft.

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Pin-connected trusses for spans from 150 ft. to 300 ft.

10. **Number of Trusses.** Unless otherwise specified, double-track through bridges shall have only two trusses or girders, and four-track bridges three.

11. **Dimensions for Calculation.** The dimensions for the calculation of stresses shall be as follows:

Span Length

For trusses and girders, the distance center to center of end bearings.

For floor beams, the distance center to center of trusses or girders.

For stringers, the distance center to center of floor beams.

Depth

For riveted trusses, the distance between centers of gravity of chord sections.

For pin-connected trusses, the distance center to center of chord pins.

For plate girders, floor beams and stringers, the distance between centers of gravity of flanges, but not to exceed the distance back to back of the flange angles.

12. **Spacing of Trusses, Girders and Floor Beams.** The width center to center of girders or trusses shall be not less than 1/15 of the effective span, and not less than is necessary to prevent overturning under the assumed lateral loading. Panel lengths shall not exceed 1½ times the width c. to c. of trusses or girders.

13. **Clearances.** If the alinement is straight, clearances shall be not less than shown on the diagram, Fig. 1. If the alinement is curved, the width of the diagram shall be increased so as to provide the same minimum clearances for a car 80 ft. long, 14 ft. high and 60 ft. center to center of trucks, allowance being made for curvature and superelevation of rails. The height of rail shall be assumed as 6 in.

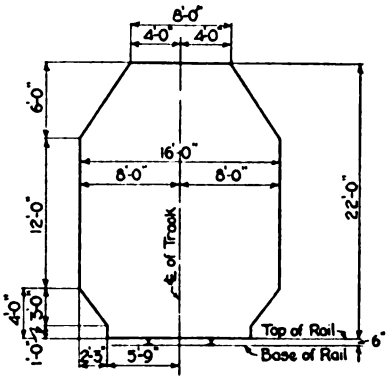


Fig. 1. Clearance Diagram

14. Deck Spans on curves shall have the center line of the span placed, usually, so as to bisect the middle ordinate of and be parallel with the chord of the curve.

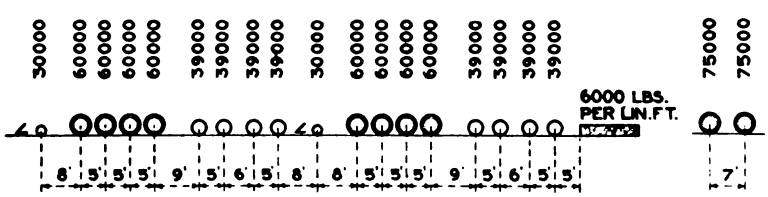
15. **Skew Bridges.** In skew bridges without ballasted floors, the ends of stringers or girders for each track shall be square with the track.

16. **Ambiguity of Stress.** Structures shall be designed so as to avoid, as far as practicable, ambiguity in the determination of the stresses.

Loads

17. **Loads.** The structures shall be proportioned for the following loads:

(a) The dead load.
(b) The live load.
(c) The impact or dynamic effect of the live load.
(d) The lateral loads and forces.
(e) The centrifugal force, including impact.
(f) The longitudinal force.



Figures 2 and 3, Loading Diagram

Stresses due to these loads and forces shall be shown separately on the stress sheets.

18. Members shall be proportioned for that combination of stresses which gives the maximum total stress, except as otherwise provided.

19. **Dead Load.** The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lb. per ft. B. M., ballast 120 lb. per cu. ft., reinforced concrete 150 lb. per cu. ft., waterproofing 150 lb. per cu. ft., and rails and fastenings 150 lb. per linear foot of track. If ballast is used, it shall be assumed level with the base of rail and the weight of the ties shall be neglected. Ballasted floors shall have at least 6 in. of ballast under the ties.

20. **Live Load.** The minimum live load for each track shall be as shown in Figs. 2 and 3, except as modified in Article 21.

The loading that gives the larger stresses shall be used.

21. In special locations, where the conditions limit the loading to light engines, a lighter loading, as stipulated by the engineer, may be used, but not in any case lighter than three-fourths of that specified in Article 20.

22. Other live loadings shall be proportional to the loading specified in Article 20 with the same wheel spacing.

23. **Multiple Tracks.** In calculating the maximum stresses due to live load and centrifugal force when two, three or four tracks are simultaneously loaded, use the following percentages of the specified live load:

For two tracks, loaded, 90 per cent.
For three tracks, loaded, 80 per cent.
For four tracks, loaded, 75 per cent.

24. **Floors.** Wooden ties shall be designed for the maximum wheel load specified distributed over three ties and with 100 per cent impact added. The fiber stress shall not exceed 2,000 lb. per sq. in. The ties shall be not less than 10 ft. in length. They shall be placed with openings not to exceed 4 in. in width and shall be secured against bunching. The maximum dap of ties shall be 1¼ in.

25. Floors consisting of beams transverse to the axis of the structure shall be designed for a uniform live load of 15,000 lb. per linear foot for each track, when the minimum live load specified in Article 20 is used. When heavier loadings are used, this uniform load shall be increased proportionately.

26. Floors consisting of longitudinal beams shall be designed for the wheel loads specified.

27. In ballasted floor bridges, the live load shall be considered as uniformly distributed laterally over a width of 10 ft.

28. **Impact.** The dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula,

$$I = S\frac{300}{300+\frac{L^2}{100}}, \text{ in which}$$

I=impact or dynamic increment to be added to the live-load stress.
S=computed maximum live-load stress.
L=the length in feet of the portion of the span which is loaded to produce the maximum stress in the member.

29. For bridges designed exclusively for electric traction, the impact stresses shall be taken as one-half of those given by the formula in Article 28.

30. Impact shall not be added to stresses produced by longitudinal or lateral forces.

31. **Eccentricity of Load on Curves.** For bridges on curves, provision shall be made for the increased load carried by any truss, girder or stringer due to the eccentricity of the load.

32. **Lateral Forces.** The lateral (or wind) force shall consist of a moving

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load equal to 30 lb. per sq. foot on 1½ times the vertical projection of the structure on a plane parallel with its axis (but never less than 200 lb. per linear ft. at the loaded chord, and 150 lb. per linear ft. at the unloaded chord), and a moving load of 700 lb. per linear ft. applied 8 ft. above the base of rail.

33. If a moving load of 50 lb. per sq. ft. on 1½ times the vertical projection of the unloaded structure on a plane parallel with its axis produces greater stresses than the lateral force defined in Article 32, it shall be provided for.

34. In calculating the stresses in viaduct towers due to lateral force, the viaduct shall be considered as loaded on either one or both tracks, with empty cars weighing 1,200 lb. per linear ft.

35. The lateral bracing between compression chords or flanges shall be capable of resisting a transverse shear in any panel equal to 2½ per cent of the total axial stress in the chords in that panel.

36. **Centrifugal Forces.** On curves, the centrifugal force (assumed to act 6 ft. above the rail) shall be taken equal to a percentage of the live load, including impact, according to the following table:

	0°	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
Degree of Curve.....	20′	40′												
Percentage	2½	5	7½	10	10	10	10	10	10	10	10	10	10	10
Speed in miles, hour	80	80	80	65	53	46	41	38	35	33	31	29	28	27

37. **Longitudinal Force.** Provision shall be made in the design for the effect of a longitudinal force of 20 per cent of the live load on one track only, applied 6 ft. above the top of the rail. In structures (such as ballasted deck bridges of only three or four spans) where, by reason of continuity of members or frictional resistance, the longitudinal force will be largely directed to the abutments, its effect on the superstructure shall be taken as one-half that specified above.

Unit Stresses and Proportioning of Parts

38. The several parts of structures shall be so proportioned that the unit stresses will not exceed the following, except as modified in Articles 46 and 47:

	Pounds per sq. in.
Axial tension, net section	16,000
Axial compression, gross section	$15{,}000-50\frac{l}{r}$
but not to exceed	12,500

l=the length of the member in inches.
r=the least radius of gyration of the member in inches.

Tension in extreme fibers of rolled shapes, built sections and girders, net section	16,000
Tension in extreme fibers of pins	24,000
Shear in plate girder webs, gross section	10,000
Horizontal shear in flange angles of girders	4,000
Shear in power-driven rivets and pins.	12,000
Bearing on power-driven rivets, pins, outstanding legs of stiffener angles, and other steel parts in contact	24,000

The above mentioned values for shear and bearing shall be reduced 25 per cent for countersunk rivets, hand-driven rivets, floor-connection rivets, and turned bolts.

Bearing on expansion rollers, per linear in. 600d
d=the diameter of rollers in inches.

	Pounds per sq. in.
Bearing on granite masonry	800
Bearing on sandstone and limestone masonry	400
Bearing on concrete masonry	600

39. **Unit Stresses and Proportioning of Parts.** For cast steel in shoes and bearings, the above mentioned unit stresses shall apply.

40. The diagonal tension in webs of girders and rolled beams at sections where maximum shear and bending occur simultaneously, shall not exceed 16,000 lb. per sq. in.

41. The effective bearing area of a pin, a bolt or a rivet shall be its diameter multiplied by the thickness of the piece, except that for countersunk rivets half the depth of the countersink shall be omitted.

42. **Effective Diameter of Rivets.** In proportioning rivets, the nominal diameter of the rivet shall be used.

43. **Proportioning Web Members.** In proportioning web members of trusses, use two-thirds of the dead load stress plus one and one-sixth times the live load stress, including impact, where this sum is greater than the sum of the dead load stress and the live load stress, including impact.

44. **Reversal of Stress.** Members subject to reversal of stress under the passage of the live load shall be proportioned as follows:

Determine the resultant tensile stress and the resultant compressive stress and increase each by 50 per cent of the smaller; then proportion the member so that it will be capable of resisting either increased resultant stress. The connections shall be proportioned for the sum of the resultant stresses.

45. **Combined Stresses.** Members subject to both axial and bending stresses (including bending due to floor beam deflection) shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress. In members continuous over panel points, only three-fourths of the bending stress computed as for simple beams shall be added to the axial stress.

46. Members subject to stresses produced by a combination of dead load, live load, impact and centrifugal force, with either lateral or longitudinal forces, or bending due to lateral action, may be proportioned for unit stresses 25 per cent greater than those specified in Article 38; but the section shall not be less than that required for dead load, live load, impact and centrifugal force.

47. **Secondary Stresses.** Designing and detailing shall be done so as to avoid secondary stresses as far as possible. In ordinary trusses without sub-paneling, no account usually need be taken of the secondary stresses in any member whose width measured in the plane of the truss is less than one-tenth of its length. Where this ratio is exceeded, or where sub-paneling is used, secondary stresses due to deflection of the truss shall be computed. The unit stresses specified in Article 38 may be increased one-third for a combination of the secondary stresses with the axial stresses.

48. **Compression Flanges.** The gross area of the compression flanges of plate girders shall not be less than the gross area of the tension flanges, but the stress per sq. in. shall not exceed

$$14{,}000-200\frac{l}{b}, \text{ in which}$$

l=the length of the unsupported flange, between lateral connections or knee braces.
b=the flange width.

Details of Design

49. **Limiting Lengths of Members.** The ratio of length to least radius of gyration shall not exceed 100 for main compression members nor 120 for wind and sway bracing.

50. The lengths of riveted tension members shall not exceed 200 times their least radius of gyration.

51. **Depth Ratios.** The depth of trusses preferably shall be not less than one-tenth of the span. The depth of plate girders preferably shall be not less than one-twelfth of the span. The depth of rolled beams used as girders and the depth of solid floors preferably shall be not less than one-fifteenth of the span. If less depths than these are used, the section must be increased so that the maximum deflection will not be greater than if these limiting ratios had not been exceeded.

52. **Parts Accessible.** Details shall be designed so that all parts will be accessible for inspection, cleaning and painting. Closed sections shall be avoided wherever possible.

53. Pockets or depressions which would hold water shall have efficient drain holes, or shall be filled with concrete.

54. Members shall be connected so that their gravity axes will intersect in a point. Eccentric connec-

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tions shall be avoided if practicable, but, if unavoidable, the members shall be proportioned so that the combined fiber stress will not exceed the allowed axial stress.

55. **Effective Area of Angles.** The effective area of single angles in tension shall be assumed as the net area of the connected leg plus 50 per cent of the area of the unconnected leg. Single angles connected by lug angles shall be considered as connected by one leg.

56. **Counters.** If web members are subject to reversal of stress, their end connections preferably shall be riveted. Adjustable counters shall have open turnbuckles.

57. **Strength of Connections.** Connections shall have a strength at least equal to that of the members connected, regardless of the computed stress. Connections shall be made, as nearly as practicable, symmetrical about the axis of the members.

58. **Limiting Thickness of Metal.** Metal shall not be less than ⅜-in. thick, except for fillers. Metal subject to marked corrosive influences shall be increased in thickness or protected against such influences.

59. **Sizes of Rivets.** Rivets shall be ¾ in., ⅞ in. or 1 in. in diameter as specified.

60. **Pitch of Rivets.** The minimum distance between centers of rivet holes shall be three diameters of the rivet, but the distance preferably shall be not less than 3½ in. for 1-in. rivets, 3 in. for ⅞-in. rivets, and 2½ in. for ¾-in. rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be 7 in. for 1-in. rivets, 6 in. for ⅞-in. rivets, and 5 in. for ¾-in. rivets. For angles with two gage lines and rivets staggered, the maximum pitch in each line shall be twice the amounts given above. If two or more web plates are used in contact, stitch rivets shall be provided to make them act in unison. In compression members, the stitch rivets shall be spaced not more than 24 times the thickness of the thinnest plate in the direction perpendicular to the line of stress, and not more than 12 times the thickness of the thinnest plate in the line of stress. In tension members, the stitch rivets shall be not more than 24 times the thickness of the thinnest outer plate in either direction. In tension members composed of two angles in contact, a pitch of 12 in. may be used for riveting the angles together.

61. **Edge Distance.** The minimum distance from the center of any rivet hole to a sheared edge shall be: 1¾ in. for 1-in. rivets, 1½ in. for ⅞-in. rivets, and 1¼ in. for ¾ in. rivets; to a rolled edge 1½ in., 1¼ in. and 1⅛ in., respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 inches.

62. **Size of Rivets in Angles.** The diameter of the rivets in any angle whose size is determined by calculated stress shall not exceed one-fourth of the width of the leg in which they are driven. In angles whose size is not so determined 1-in. rivets may be used in 3½-in. legs, ⅞-in. rivets in 3-in. legs, and ¾-in. rivets in 2½-in. legs.

63. **Long Rivets.** Rivets which carry calculated stress and whose grip exceeds four and one-half diameters shall be increased in number at least one per cent for each additional ⅛-in. of grip. If the grip exceeds six times the diameter of the rivet, specially designed rivets shall be used.

64. **Pitch of Rivets at Ends.** The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivet for a distance equal to one and one-half times the maximum width of the member.

65. **Compression Members.** In built compression members, the metal shall be concentrated in the webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between the lines of rivets connecting it to the flanges. The thickness of cover plates shall be not less than one-fortieth of the distance between the nearest rivet lines.

66. **Outstanding Legs of Angles.** The width of the outstandings legs of angles in compression (except when reinforced by plates) shall not exceed the following:

a. For stringer flange angles, ten times the thickness.

b. For main members carrying axial stress, twelve times the thickness.

c. For bracing and other secondary members, fourteen times the thickness.

67. **Stay Plates.** The open sides of compression members shall be provided with lacing bars and shall have stay plates as near each end as practicable. Stay plates shall be provided at intermediate points where the lacing is interrupted. In main members, the length of the stay plates shall be not less than 1¼ times the distance between the lines of rivets connecting them to the outer flanges, and the length of intermediate stay plates shall be not less than three-fourths of that distance. Their thickness shall be not less than one-fiftieth of the same distance.

68. Tension members composed of shapes shall have their separate segments stayed together. The stay plates shall have a length not less than two-thirds of the lengths specified for stay plates on compression members.

69. **Lacing.** The lacing of compression members shall be proportioned to resist a shearing stress of 2½ per cent of the direct stress. The minimum width of lacing bars shall be 3 in. for 1-in. rivets, 2¼ in. for ⅞-in. rivets, 2½ in. for ¾-in. rivets, and 2 in. for ⅝-in. rivets. The thickness shall be made as required by Article 38, in which "l" shall be taken as the distance between connections to the main sections.

70. In members composed of side segments and a cover plate, with the open side laced, one-half the shear shall be considered as taken by the lacing. Where double lacing is used, the shear in the plane of the lacing shall be equally distributed between the two systems.

71. Lacing bars of compression members shall be so spaced that the $\frac{l}{r}$ of the portion of the flange included between their connections will be not greater than 40, and not greater than two-thirds of the $\frac{l}{r}$ of the member.

72. In connecting lacing bars to flanges, ⅝-in. rivets shall be used for flanges less than 2½ in. wide, ¾-in. rivets for flanges from 2½ to 3½ in. wide, and ⅞-in. rivets for flanges 3½ or more inches wide. Lacing bars with at least two rivets in each end shall be used for flanges over 5 in. wide.

73. The angle of lacing bars with the axis of the member shall be not less than 45 deg. for double lacing, and 60 deg. for single lacing. If the distance between rivet lines in the flanges is more than 15 in. and a single-rivet bar is used, the lacing shall be double and riveted at the intersections.

74. **Splices.** Abutting joints in compression members faced for bearing shall be spliced on four sides. The gross area of the splice material shall be not less than 50 per cent of the gross area of the smaller member.

75. Joints in riveted work not faced for bearing, whether in tension or compression, shall be fully spliced.

76. **Net Section at Pins.** In pin connected riveted tension members, the net section across the pin hole shall be not less than 140 per cent and the net section back of the pin hole not less than 100 per cent of the net section of the body of the member, and there shall be sufficient rivets to make the material effective.

77. The net section of riveted members shall be the least area which can be obtained by deducting from the gross sectional area the areas of holes cut by any plane perpendicular to the axis of the member and parts of the areas of other holes on one side of the plane within a distance of 4 in., which are on gage lines 1 in. or more from those of the holes cut by the plane, the parts being determined by the formula:

$$A\left[1-\frac{P}{4}\right], \text{ in which}$$

A=the area of the hole.

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P=the distance in inches of the center of the hole from the plane.

78. In determining the net section, the diameter of the rivet hole shall be taken ⅛ in. larger than the nominal diameter of the rivet.

79. **Pin Plates.** Where necessary to give the required section or bearing area, pin holes shall be reinforced on each segment by plates, one of which on each side must be as wide as the outstanding flanges will permit. These plates shall contain enough rivets and be so connected as to transmit and distribute the bearing pressure uniformly over the full cross section and to reduce the eccentricity of the segment to a minimum. At least one full-width plate on each segment shall extend to the far edge of the stay plate and the others not less than 6 in. beyond the near edge.

80. **Indirect Splices.** If splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the point in excess of the number required in the case of direct contact to the extent of two extra lines for each intervening plate.

81. **Fillers.** Where rivets carrying stress pass through fillers, the fillers shall be extended beyond the connected member and the extension secured by additional rivets sufficient to develop the value of the filler.

82. Forked ends on compression members will be permitted only where unavoidable. Where forked ends are used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member and they shall be extended as far as necessary in order to carry the stress of the main member into the jaws, but shall not be shorter than required by Article 79.

83. Pins shall be long enough to secure a full bearing of all parts connected upon the turned body of the pin. They shall be secured by chambered nuts or by solid nuts with washers. Where the pins are bored, through rods with cap washers may be used. The screw ends shall be long enough to admit of burring the threads.

84. Pin connected members shall be held against lateral movement on the pins.

85. **Bolts.** Where members are connected by bolts, the turned bodies of the bolts shall be long enough to extend through the metal. A washer at least ¼ in. thick shall be used under the nut. Bolts shall not be used except by special permission.

86. **Upset Ends.** Bars with screw ends shall be upset so that the area at the root of the thread will be at least 15 per cent larger than in the body of the bar.

87. Sleeve nuts shall not be used.

88. **Expansion.** Provision shall be made for expansion and contraction at the rate of 1 in. for every 100 ft. in length. The expansion ends shall be secured against lateral movement. In spans more than 250 ft. in length, provision shall be made for expansion in the floor.

89. **Expansion Bearings.** Spans more than 70 ft. in length shall have rollers at one end. Spans of less length shall be arranged to slide on smooth surfaces.

90. **Fixed Bearings.** Bearings and ends of spans shall be secured against lateral motion.

91. **Rollers.** Expansion rollers shall be not less than 6 in. in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be cleaned readily. Rollers shall be geared to the upper and lower plates.

92. Pedestals and shoes preferably shall be made of cast steel. The difference between the top and bottom bearing widths shall not exceed twice the depth. For hinged bearings, the depth shall be measured from the center of the pin. Where built pedestals and shoes are used, the web plates and the angles connecting them to the base plate shall be not less than ¾ in. thick. If the size of the pedestal permits, the webs shall be rigidly connected transversely. The minimum thickness of the metal in cast steel pedestals shall be 1 in. Pedestals and shoes shall be so constructed that the load will be distributed uniformly over the entire bearing. Spans more than 70 ft. in length shall have hinged bearings at each end.

93. **Inclined Bearings.** For spans on an inclined grade and without hinged bearings, the sole or masonry plates shall be beveled so that the masonry surfaces will be level.

94. There shall be a name plate, showing in raised letters and figures the name of the manufacturer and the year of construction, bolted to the bridge near each end at a point convenient for inspection.

Floors

95. Floors may consist of steel floor-beams and stringers, with timber cross-ties supporting the rails, or of one of the solid floor types.

96. Floor members shall be designed with special reference to stiffness.

97. Specifications for plate girders shall apply to floor-beams and stringers.

98. Stringers usually shall be spaced 6 ft. 6 in. center to center. If four stringers are used under one track, each pair shall be spaced symmetrically about the rail.

99. **I-Beam Girders.** Rolled beams supporting timber decks shall be arranged with not more than four, and preferably not less than two beams under each rail. The beams in each group shall be placed symmetrically about the rail, and shall be spaced sufficiently far apart to permit cleaning and painting. They shall be connected by solid web diaphragms near the ends and at intermediate points, spaced not over twelve times the flange width. Bearing plates shall be continuous under each group of beams. End stiffeners shall be used if required by the provisions of Article 38.

100. **Floor-Beam Connections.** Floor-beams preferably shall be square to the girders or trusses. They shall be riveted directly to the girders or between the posts of through and deck truss spans.

101. **End Connection Angles.** The legs of stringer connection angles shall be not less than 4 in. in width, and not less than ⅝ in. in thickness before facing. Shelf angles shall be provided to support the stringers during erection, but the connection angles shall be sufficient to carry the whole load. Stringers in through spans shall be riveted between the floor-beams.

102. **Stringer Frames.** Where two lines of stringers are used under each track in panels more than 20 ft. in length, they shall be connected by cross frames.

103. **Solid Floor Connections.** Solid floors shall be connected to the girders or trusses by angles not less than ⅝ in. thick if to be faced, or ½ in. thick if not to be faced; one angle on each side of the web of I-beams and one on each of the vertical members of troughs.

104. Solid floors shall be proportioned by the moments of inertia of the sections, using the net sections including the compression side.

Bracing

105. **Design of Bracing.** Lateral, longitudinal and transverse bracing shall be composed of shapes with riveted connections. Lateral bracing shall have concentric connections to chords at end joints, and preferably throughout. The connections between the lateral bracing and the chords shall be designed to avoid, as far as practicable, any bending stress in the truss members.

106. When a double system of bracing is used, both systems may be considered simultaneously effective if the members meet the requirements, both as tension and compression members.

107. **Lateral Bracing.** Bottom lateral bracing shall be provided in all bridges except deck plate girder spans less than 50 ft. long, from which it may be omitted. Continuous steel or concrete floors will be considered lateral bracing.

108. The top lateral bracing shall be provided in deck spans and in through spans having sufficient head room.

109. **Portal and Sway Bracing.** Deck truss spans shall have vertical sway bracing at each panel point. They shall also have bracing in the planes of the end posts. The end reaction of the top lateral system

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shall be carried through the vertical end bent to the masonry.

110. Through truss spans shall have portal bracing, with knee braces, as deep as the specified clearance will allow.

111. Through truss spans shall have sway bracing at each intermediate panel point if the height of the trusses is such as to permit of a depth of 6 ft. or more for the bracing. When the height of the trusses will not permit of such depth, the top lateral struts shall be of the same depth as the chord and shall have knee braces.

112. **Cross-Frames.** Deck plate girder spans shall be provided with cross-frames at each end proportioned to resist centrifugal and lateral forces, and shall have intermediate cross-frames at intervals not exceeding 18 ft.

113. **Laterals.** The smallest angle to be used in lateral bracing shall be 3½ in. by 3 in. by ⅜ in. There shall be not less than three rivets at each end connection of the angles. Angles shall be connected at their intersections by plates.

114. **Clearance.** Lateral bracing beneath the track shall be low enough to clear the ties.

Plate Girders

115. **Spacing of Girders.** The girders of deck bridges usually shall be spaced 6 ft. 6 in. between centers, except that:

a. In single-track deck spans 75 ft. or more in length, the girders shall be spaced in accordance with paragraph 12, but not less than 7 ft. 6 in. between centers.

b. In bridges on curves, the girders shall be spaced as shown on the plans.

116. **Design of Plate Girders.** Plate girders shall be proportioned either by the moment of inertia of their net section, including compression side; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case, one-eighth of the gross section of the web, if properly spliced, may be used as flange section. For girders having unusual sections, the moment of inertia method shall be used.

117. **Flange Sections.** The flange angles shall form as large a part of the area of the flange as practicable. Side plates shall not be used except when flange angles exceeding 1 in. in thickness otherwise would be required.

118. Flange plates shall be equal in thickness, or Side plates shall not be used except when flange angles outward. No plate shall have a thickness greater than that of the flange angles.

119. Where flange cover plates are used, one cover plate of the top flange shall extend the full length of the girder. Other flange plates shall extend at least 18 in. beyond the theoretical end.

120. The thickness of web plates shall be not less than $\frac{1}{20}\sqrt{D}$, where "D" represents the distance between flanges in inches.

121. **Flange Rivets.** The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer to the flange section the horizontal shear at any point combined with any load that is applied directly on the flange. One wheel load, where ties rest on the flange, shall be assumed to be distributed over 3 feet.

122. **Flange Splices.** Splices in flange members shall not be used except by special permission of the engineer. Two members shall not be spliced at the same cross-section and, if practicable, splices shall be located at points where there is an excess of section. The net section of the splice shall exceed by 10 per cent the net section of the member spliced. Flange angle splices shall consist of two angles, one on each side.

123. **Web Splices.** Web plates shall be symmetrically spliced by plates on each side. The splice plates for shear shall be of the full depth of the girders between flanges. The splice shall be equal to the web in strength in both shear and moment. There shall be not less than two rows of rivets on each side of the joint.

124. **End Stiffeners.** Plate girders shall have stiffener angles over end bearings, the outstanding legs of which shall extend as nearly as practicable to the outer edge of the flange angles. These end stiffeners shall be proportioned for bearing of the outstanding legs on the flange angles, and shall be arranged to transmit the end reaction to the pedestals or distribute it over the masonry bearings. They shall be connected to the web by enough rivets to transmit the reaction. End stiffeners shall not be crimped.

125. **Intermediate Stiffeners.** The webs of plate girders shall be stiffened by angles at intervals not greater than:

(a) Six feet.

(b) The depth of the web.

(c) The distance given by the formula $d=\frac{t}{40}(12{,}000-S)$

d=the distance between rivet lines of stiffeners in inches.

t=the thickness of the web in inches.

S=web shear in pounds per square inch at the point considered.

126. If the depth of the web between the flange angles or side plates is less than 50 times the thickness of the web, intermediate stiffeners may be omitted.

127. Stiffener angles shall be placed at points of concentrated loading. Such angles shall not be crimped.

128. Intermediate stiffeners shall be riveted in pairs to the web of the girder. The outstanding leg of each angle shall not be less than 2 in. plus one-thirtieth of the depth of the girder, nor more than 16 times its thickness.

129. **Gusset Plates in Through Girders.** In through plate girder spans, the top flanges shall be braced by means of gusset plates or knee braces with solid webs connected to the floor-beams and extending usually to the clearance line. If the unsupported length of the inclined edge of the gusset plate exceeds 18 in., the gusset plate shall have one or two stiffening angles riveted along its edge. The gusset plate shall be riveted to a stiffener angle on the girder. Preferably it shall form no part of the floor-beam web.

130. In through plate girder spans with solid floors, there shall be knee braces with ⅜-in. webs, extending usually to the clearance line, at intervals of about 12 ft. Each knee brace shall be well riveted to the floor and the girder, especially at the top, and shall have its edge reinforced by one or two angles.

131. **Ends of Through Girders.** If through plate girders project 2 ft. or more above the base of the rail, the upper corners shall be rounded. In multiple span bridges, usually only the extreme ends shall be rounded. Exposed ends of through girders shall be neatly finished with end plates.

132. **Spans Shipped Riveted.** Deck plate girder spans less than 50 ft. in length shall be shipped riveted complete, unless otherwise specified.

133. **Masonry Bearings.** End bearings on masonry preferably shall be raised above the coping by metal pedestals.

134. Sole plates shall be not less than ¾ in. thick and not less in thickness than the flange plus ⅛ in. They shall not be longer than 18 in.

135. **Anchor Bolts.** Anchor bolts shall be 1¼ in. diam. and shall extend 12 in. into the masonry. There shall be washers under the nuts. Anchor bolt holes in pedestals and sole plates shall be 1⅝ in. in diameter, except that at expansion points the holes in the sole plates shall be slotted.

Trusses

136. **Type of Truss and Sections of Members.** Trusses shall have single intersection web systems and, preferably, inclined end posts. The top chords and end posts shall be made usually of two side segments with one cover plate and with stay plates and lacing on the open side. The bottom chords of riveted trusses shall be symmetrically made, usually of

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vertical side plates with flange angles. Web members shall be made of symmetrical sections.

137. **Camber.** The length of members of truss spans shall be such that the camber will be equal to the deflection produced by the combined dead and live loads without impact.

138. **Riveted Members in Pin-Connected Trusses.** In pin-connected trusses, hip verticals (and members performing similar functions) and, in single track spans, the two panels at each end of the bottom chords shall be riveted members.

139. **Eye-Bars.** The cross sectional area of the head through the center of the pin hole shall exceed that of the body of the eye-bar by at least 37½ per cent. The thickness of the bar shall be not less than one-eighth of the width nor less than 1 in., and not greater than 2 in. The form of the head shall be submitted to the engineer for approval before the bars are made. The diameter of the pin shall be not less than seven-eighths of the width of the widest bar attached.

140. **Packing.** The eye-bars of a set shall be packed symmetrically about the plane of the truss and as nearly parallel as practicable, but in no case shall the inclination of any bar to the plane of the truss exceed ⅛ in. per ft. They shall be packed as closely as practicable. They shall be held against lateral movement, and arranged so that adjacent bars in the same panel will not be in contact.

141. **Gusset Plates.** The thickness of gusset plates connecting the chords and web members of the truss shall be proportionate to the stress to be transferred, but shall not be less than ½ in.

142. **Facilities for Jacking.** Provision shall be made for lifting the span at the ends.

143. **Masonry Plates.** Masonry plates shall not be less than 1 in. thick.

Viaducts

144. **Type.** Viaducts shall consist usually of alternate tower spans and free spans of plate girders or riveted trusses supported on bents. The tower spans usually shall be not less than 30 ft. long.

145. **Bents and Towers.** Viaduct bents shall be composed preferably of two supporting columns, and the bents usually shall be united in pairs to form towers. Towers shall be braced, both transversely and longitudinally, with riveted members. In double-track towers, provision shall be made for the transmission of the longitudinal force to both ends.

146. **Single Bents.** Where long spans are supported on short single bents, such bents shall have hinged ends, or else have their columns and anchorages proportioned to resist the bending stresses produced by changes in temperature.

147. **Bottom Struts.** The bottom struts of viaduct towers shall be proportioned for the calculated stresses, but in no case for less than one-fourth of the dead load reaction on one pedestal, considered as compressive stress. Provision shall be made in the column bearings for expansion of the tower bracing.

148. **Batter.** The columns usually shall have a batter transversely of one horizontal to six vertical for single track viaducts, or one horizontal to eight vertical for double track viaducts.

149. The depths of girders in viaducts preferably shall be uniform.

150. **Spacing of Girders.** In single track viaducts, the girder spacing usually shall be uniform throughout, and shall be determined by the spacing for the longest span in the viaduct, according to the rules specified for deck plate girder spans.

151. In double track viaducts, the girders under each track usually shall be spaced 6 ft. 6 in. between centers, and the inner lines of girders shall be supported by cross-girders framed between and riveted to the posts.

152. **Girder Connections and Bracing.** Girders of tower spans shall be fastened at each end to the tops of the posts or cross-girders. Girders between towers shall have one end riveted, and shall be provided with an effective expansion joint at the other end. No bracing or sway frame shall be common to abutting spans.

153. If neither of the girders under a track rests directly over a tower post, bracing shall be provided to carry the longitudinal force into the tower bracing without producing lateral bending stress in the cross girders or posts.

154. Sole and masonry plates shall be not less than ¾ in. thick.

155. **Anchorage for Towers.** Anchor bolts for viaduct towers and similar structures shall be designed to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

Materials*

Structural and Rivet Steel

156. **Process.** Structural and rivet steel shall be made by the open-hearth process.

157. **Properties.** Test specimens of structural and rivet steel shall (except as modified in Articles 160, 163 and 164) conform to the following requirements as to chemical and physical properties:

	Structural Steel	Rivet Steel
Phosphorus, maximum		
Acid	0.06 per cent	0.04 per cent
Basic	0.04 per cent	0.04 per cent
Sulphur, maximum	0.05 per cent	0.045 per cent
Tensile strength, lb. per sq. in.	55,000 to 65,000	46,000 to 56,000
Yield point, lb. per sq. in., minimum	30,000	25,000
Elongation in 8 in., min., %	1500000 / Tens. Str.	1500000 / Tens. Str.

158. **Ladle Analyses.** An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the engineer.

159. **Check Analyses.** Analyses may be made by the engineer from finished material representing each melt. The phosphorus and sulphur content thus determined shall not exceed that specified in Article 157 by more than 25 per cent.

160. **Specimen Tension Tests of Eye-Bar Material.** In order to meet the minimum tensile strength of full size annealed eye-bars required in Article 284, the contractor may determine the tensile strength to be obtained in specimen tests, the range not to exceed 14,000 lb. per sq. in. and the maximum not to exceed 74,000 lb. per sq. in. The material shall conform to the requirements as to physical properties other than that of tensile strength as specified in Articles 157, 163 and 166.

161. The yield point shall be determined by the drop of the beam of the testing machine.

162. **Speed of Testing Machine.** The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but in no case shall the values given in the following table be exceeded:

Gage Length of Specimen	Maximum Cross-head Speed (Ins. per min.) in Determining: Yield Point	Tensile Strength
8 in.	0.5	2.0
2 in.	2.0	6.0

163. **Modifications in Elongation.** For structural steel over ¾ in. in thickness, a deduction of one from the percentage of elongation in 8 in. specified in Article 157 shall be made for each increase of ⅛ in. in thickness above ¾ in. to a minimum of 18 per cent.

164. For structural steel under ⅝ in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Article 157 shall be made for each decrease of ⅛ in. in thickness below ⅝ in.

*Specifications for materials conform to A. S. T. M. Standards, Serials A7-16, A27-16 and A-48-18, except as to the yield point requirements and Articles 178 and 179.

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165. **Bend Tests.** The test specimens for plates, shapes, and bars (except as specified in Articles 166, 167 and 168) shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows:

(a) For material ¾ in. or less in thickness, flat on itself.

(b) For material more than ¾ in. to and including 1¼ in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

(c) For material more than 1¼ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

166. The test specimens for eye-bar flats shall bend cold through 180 deg. without cracking on the outside of the bent portion as follows:

(a) For material ¾ in. or less in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

(b) For material more than ¾ in. to and including 1¼ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

(c) For material more than 1¼ in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen.

167. The test specimens for pins, rollers and other bars, when prepared as specified in Article 173, shall

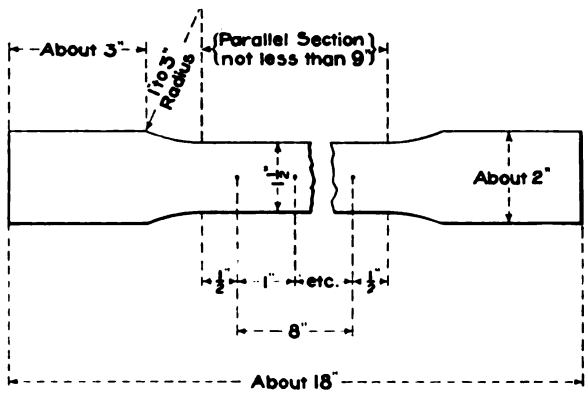

Fig. 5.

bend cold through 180 deg. around a 1 in. pin without cracking on the outside of the bent portion.

168. The test specimens for rivet steel shall bend cold through 180 deg. flat on themselves without cracking on the outside of the bent portion.

169. **Test Specimens.** Tension and bend test specimens shall be taken from rolled steel in the condition in which is comes from the rolls, except as specified in Article 170.

170. Tension and bend test specimens for pins and rollers shall be taken from the finished bars after annealing when annealing is specified.

171. Tension and bend test specimens for plates, shapes and bars (except as specified in Articles 172, 173 and 174) shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. 5, or with both edges parallel, except that bend test specimens for eye-bar flats may have three rolled sides.

172. Tension and bend test specimens for plates and tension test specimens for eye-bar flats more than 1½ in. in thickness may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in.

173. Tension test specimens for pins, rollers, and bars (except eye-bar flats) over 1½ in. in thickness or diameter may conform to the dimensions shown in Fig. 6. In this case, the ends shall be of a form to fit the holders of the testing machine in such a way that the load will be axial. Bend test specimens may be 1 by ½ in. in section. The axis of the specimen shall be located at any point midway between the center and surface and shall be parallel with the axis of the bar.

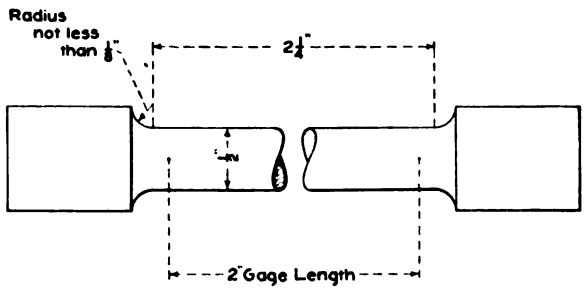

Fig. 6.

Note.—The gage length, parallel portions and fillets shall be as shown, but the ends may be of any form which will fit the holders of the testing machine.

174. Tension and bend test specimens for rivet steel shall be of the full-size section of the bars as rolled.

175. **Number of Tests.** One tension and one bend test shall be made from each melt, except that if material from one melt differs ⅜ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

176. If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

177. If the percentage of elongation of any tension test specimen is less than that specified in Article 157, and any part of the fracture is more than ¾ in. from the center of the gage length of a 2 in. specimen or is outside the middle third of the gage length of an 8 in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

178. **Character of Fracture.** Test specimens of structural or rivet steel shall show a fracture of uniform, silky appearance, of bluish gray or dove color,

TABLE I — PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT

ORDERED WEIGHT, Lb. Per Sq. Ft.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS.																	
	Under 48 In.		48 to 60 In., Excl.		60 to 72 In., Excl.		72 to 84 In., Excl.		84 to 96 In., Excl.		96 to 108 In., Excl.		108 to 120 In., Excl.		120 to 132 In., Excl.		132 In. or Over	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...
5 to 7.5, excl	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...
7.5 to 10, excl	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...
10 to 12.5, excl	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3
12.5 to 15, excl	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3
15 to 17.5, excl	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3
17.5 to 20, excl	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3
20 to 25, excl	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3
25 to 30, excl	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3
30 to 40, excl	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3

NOTE—The weight per sq. ft. of individual plates shall not vary from the ordered weight by more than 1½ times the amount given in this table.

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TABLE II—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS

ORDERED THICKNESS, Inches.	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHTS.								
	Under 48 in.,	48 to 60 in., Excl.	60 to 72 in., Excl.	72 to 84 in., Excl.	84 to 96 in., Excl.	96 to 108 in., Excl.	108 to 120 in., Excl.	120 to 132 in., Excl.	132 in. or Over
Under 1/8	9	10	12	14	.....	.....	.....	.....	.....
1/8 to 3/16, excl.	8	9	10	12	.....	.....	.....	.....	.....
3/16 to 1/4, excl.	7	8	9	10	12	.....	.....	.....	.....
1/4 to 5/16, excl.	6	7	8	9	10	12	14	16	19
5/16 to 3/8, excl.	5	6	7	8	9	10	12	14	17
3/8 to 7/16, excl.	4.5	5	6	7	8	9	10	12	15
7/16 to 1/2, excl.	4	4.5	5	6	7	8	9	10	13
1/2 to 5/8, excl.	3.5	4	4.5	5	6	7	8	9	11
5/8 to 3/4, excl.	3	3.5	4	4.5	5	6	7	8	9
3/4 to 1	2.5	3	3.5	4	4.5	5	6	7	8
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7

NOTE—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than 1 1/3 times the amount given in this table.

and entirely free from granular, black and brilliant specks.

179. **Surface Defects.** Finished rolled material shall be free from cracks, flaws, injurious seams, blisters, ragged and imperfect edges, and other surface defects. It shall have a smooth finish, and shall be straightened in the mill before shipment.

180. **Permissible Variations in Weight and Thickness.** The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified, except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.:

(a) When ordered to weight per sq. ft. the weight of each lot in each shipment shall not vary from the weight ordered more than the amount given in Table I. The term "lot" as applied to Table I means all of the plates of each group width and group weight.

(b) When ordered to thickness, the thickness of each plate shall not vary more than 0.01 in. under that ordered. The overweight of each lot in each shipment shall not exceed the amount given in Table II. The term "lot" as applied to Table II means all of the plates of each group width and group thickness.

181. **Marking.** The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be separated properly and marked for identification. The identification marks shall be stamped legibly on the end of each pin and roller. The melt number shall be marked legibly by stamping if practicable, on each test specimen.

CAST STEEL

182. **Process.** Cast steel shall be made by the open-hearth or the crucible process.

183. **Heat Treatment.** Castings shall be annealed.

184. **Chemical and Physical Properties.** Test specimens of cast steel shall conform to the following requirements as to chemical composition and tensile properties:

Elements Considered	Min. Ten. Strength lb. per sq. in.	Min. Yield Point lb. per sq. in.	Min. Elongation in 2 in.	Min. Reduction of Area
Phosphorus not over 0.05%	60,000	30,000	22%	30%
Sulphur not over 0.05%				

185. **Ladle Analyses.** An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the engineer.

186. Check analyses may be made by the engineer from a broken tension or bend test specimen. The phosphorus and sulphur content thus determined shall not exceed that specified in Article 184 by more than 20 per cent. Drillings for analysis shall be taken not less than ¼ in. beneath the surface.

187. The yield point shall be determined by the drop of the beam of the testing machine. The speed of the machine shall conform to the requirements of Article 162.

188. **Bend Test.** The test specimen shall bend cold through 120 deg. around a 1 in. pin without cracking on the outside of the bent portion.

189. **Test Specimens.** Sufficient test bars from which the test specimens required by Article 192 may be selected shall be attached to castings weighing 500 lb. or more, when the design of the castings will permit. If the castings weigh less than 500 lb., or are of such a design that test bars cannot be attached, two test bars shall be cast to represent each melt. Test bars shall be annealed with the castings they represent.

190. Tension test specimens shall conform to the dimensions shown in Fig. 6.

191. Bend test specimens shall be machined to 1 in. by ½ in. in section with corners rounded to a radius not over $\frac{1}{16}$ in.

192. **Number of Tests.** One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in the annealing charge, one tension and one bend test shall be made from each melt.

193. If the percentage of elongation of any tension test specimen is less than that specified in Article 184 and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

194. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-anneal such lot not more than twice and retests shall be made as specified in Article 184.

195. **Workmanship and Finish at Foundry.** The castings shall conform substantially to the drawings and shall be made in a workmanlike manner. The castings shall be free from injurious defects. Minor defects, which do not impair the strength of the castings, may, with the approval of the engineer, be welded by an approved process. The defects first shall be cleaned out to solid metal and, after welding, the castings shall be annealed, if required by the engineer.

196. **Inspection at Foundry.** Tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

197. **Rejection.** Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

CAST IRON

198. **Process.** Cast iron shall be of tough gray iron, and shall be made by the cupola process.

199. **Finish.** Castings shall be true to pattern and free from excessive shinkage. They shall be free from cracks, cold shuts, blow holes and other flaws.

200. **Chemical Composition.** The sulphur content of cast iron shall not exceed the following:

Light castings .....0.10 per cent.
Medium castings .....0.10 per cent.
Heavy castings .....0.12 per cent.

Drillings taken from the fractured ends of the transverse test bars shall be used for the sulphur determina-

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tions. One determination shall be made from each set of bars.

201. **Classification.** Castings shall be classified as light, medium, and heavy.

(a) Light castings are those having any section less than ½ in. thick.

(b) Heavy castings are those having no section less than 2 in. thick.

(c) Medium castings are those not included in either of the two classes above.

202. **Test Bar.** Tests shall be made on the "arbitration test bar" of the American Society for Testing Materials, as shown by Fig. 1, Serial A48-18.

203. Tension tests will be made only when specified by the engineer and at the expense of the company.

204. **Number of Tests.** Two sets of two test bars each shall be cast from each melt in thoroughly dried green sand molds, one set from the first iron poured and the other set from the last iron poured. Where the melt exceeds 20 tons, an additional set of two bars shall be cast from each additional 20 tons or fraction thereof.

205. A transverse test of each bar cast shall be made. The load shall be applied at the middle, and the supports shall be spaced 12 in. apart. The load on the test bar at rupture shall be not less than the following:

Light castings .....2500 lb.
Medium castings .....2900 lb.
Heavy castings .....3300 lb.

The deflection at rupture shall in no case be less than 0.10 in. The rate of application of the load shall be such that a central deflection of 0.10 is produced in from 20 to 40 seconds.

Workmanship

206. **Class of Work.** The work shall be "punched work" or "reamed work" as stipulated.

207. **General.** The workmanship and finish shall be equal to the best general practice in modern bridge shops. Material at the shops shall be kept clean and protected from the weather as far as practicable.

208. **Straightening Material.** Rolled material, before being laid off or worked, must be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Sharp kinks and bends may be cause for rejection.

209. **Finish.** Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

210. **Punched Work.** In punched work, holes in material whose thickness is not greater than the diameter of the rivets plus ⅛ in., may be punched full size. Holes in material of greater thickness shall be drilled.

211. **Reamed Work.** In reamed work, holes in material ⅞ in. thick and less, used for lateral, longitudinal and sway bracing, lacing, stay plates and diaphragms, may be punched full size.

212. Holes in other material ¾ in. thick and less, shall be sub-punched and reamed.

213. Holes in material more than ¾ in. thick shall be drilled.

214. **Punched Holes.** Full size punched holes shall be ⅛ in. larger than the nominal diameter of the rivets. The diameter of the die shall not exceed the diameter of the punch by more than 1/32 in. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes must be clean cut, without torn or ragged edges. Poor matching of holes may be cause for rejection.

215. **Sub-Punched and Reamed Holes.** In sub-punched and reamed work, the holes shall be punched ⅛ in. smaller and, after assembling, reamed ⅛ in. larger than the nominal diameter of the rivet. The diameter of the punch used shall be ⅛ in. smaller than the nominal diameter of the rivet and the diameter of the die not more than 1/32 in. larger than the diameter of the punch. Outside burrs shall be removed with a tool making a ⅛ in. fillet.

216. **Accuracy of Punching in Reamed Work.** In sub-punched and reamed work, the punching shall be so accurately done that, after assembling and before reaming, a cylindrical in ⅛ in. smaller in diameter than the nominal size of the punched hole may be entered, perpendicular to the face of the member, without drifting, in at least 75 of any group of 100 contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces shall be rejected. If any hole will not pass a pin ⅛ in. smaller in diameter than the nominal size of the punched hole, this shall be cause for rejection.

217. **Reaming After Assembling.** Reaming shall be done after the pieces forming a built member are assembled and so firmly bolted together that the surfaces are in close contact. Before riveting, they shall be taken apart, if necessary, and any shavings removed. When it is necessary to take the members apart for shipping or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted.

218. **Accuracy of Reaming and Drilling.** When holes are reamed or drilled, 85 of any group of 100 contiguous holes in the same plane shall, after reaming or drilling, show no offset greater than 1/32 in. between adjacent thicknesses of metal.

219. Reamed holes shall be cylindrical, perpendicular to the member, and not more than 1/32 in. larger than the nominal diameter of the rivets. Reamers preferably shall not be directed by hand. Outside burrs shall be removed with a tool making a ⅛ fillet.

220. Drilled holes shall be ⅛ in. larger than the nominal size of the rivet. Burrs on the outside surfaces shall be removed.

221. **Assembling for Drilling.** Connecting parts requiring drilled holes shall be assembled and securely held together while being drilled.

222. **Shop Assembling.** The parts of riveted members shall be well pinned and firmly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. Surfaces in contact shall be painted. Bolts in field connection holes shall be left in place.

223. **Field Connections.** Solid floor sections shall be assembled to the girders or trusses, or to suitable frames, in the shop, and the end connections made to fit. (103.)

224. In reamed work, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and the holes for field connections drilled or reamed while so assembled. Holes for other field connections, except those in lateral, longitudinal and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal template.

225. In punched work, the field connections (except those in lateral, longitudinal and sway bracing) shall be reamed to metal templates.

226. **Match-Marking.** Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished the engineer.

227. **Rivets.** The size of rivets called for on the plans shall be the size of the rivet before heating.

228. Rivet heads, when not countersunk or flattened, shall be of approved shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

229. **Riveting.** Rivets shall be heated uniformly to a light cherry red and driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and carbon deposit. When driven, they shall completely fill the holes. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and, if necessary, they shall be drilled out. Calking or re-cupping will not be permitted.

230. Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed.

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231. When necessary to drive rivets with a pneumatic riveting hammer, a pneumatic bucker shall be used for holding up, when practicable.

232. **Field Rivets.** Field rivets shall be furnished in excess of the nominal number required to the amount of 15 per cent plus 10 rivets, for each size and length.

233. Field rivets shall be carefully selected, and shall be free from fins on the under side of the head.

234. **Turned Bolts.** Where turned bolts are used to transmit shear, the holes shall be reamed parallel and the bolts shall make a tight fit with the threads entirely outside of the holes. A washer not less than ¼ in. thick shall be used under each nut.

235. **Planing Sheared Edges.** Sheared edges of material more than ⅝ in. in thickness and carrying calculated stress shall be planed to a depth of ¼ in. Re-entrant cuts shall be filleted before cutting.

236. **Lacing Bars.** The ends of lacing bars shall be neatly rounded, unless otherwise called for.

237. **Fit of Stiffeners.** Stiffeners under the top flanges of deck girders and at all bearing points, shall be milled or ground to bear against the flange angles. Other stiffeners must fit sufficiently tight against the flange angles to exclude water after being painted. Fillers and and splice plates shall fit within ¼ in. at each end.

238. **Web Plates.** Web plates of girders which have no cover plates may be ⅛ in. above or below the backs of the top flange angles. Web plates of girders which have cover plates may be ½ in. less in width than the distance back to back of flange angles.

239. When web plates are spliced, not more than ⅜ in. clearance between ends of plates will be allowed.

240. **Facing Floor Beams, Stringers and Girders.** Floor beams, stringers and girders having end connection angles shall be made of exact length after the connection angles are riveted. If facing is necessary, the thickness of the angles shall not be reduced more than ⅛ in. at any point.

241. Finished members shall be true to line and free from twists, bends and open joints.

242. **Abutting Joints.** Abutting joints in compression members and girder flanges and where so specified on the drawings, in tension members, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed ¼ in.

243. **Eye-Bars.** Eye-bars shall be straight, true to size, and free from twists, folds in the neck or head, and other defects. The heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of the heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the engineer, but the manufacurer shall guarantee the bars to break in the body under the requirements of the full size tests. The thickness of the head and neck shall not overrun more than $\frac{1}{16}$ in. for bars 8 in. or less in width, ⅛ in. for bars more than 8 in. and not more than 12 in. in width, and $\frac{3}{16}$ in. for bars more than 12 in. wide.

244. Eye-bars which are to be placed side by side in the structure shall be bored so accurately that, upon being placed together, the pins will pass through the holes at both ends at the same time without driving. Eye-bars shall have both ends bored at the same time.

245. **Annealing.** Eye-bars shall be annealed by heating uniformly to the proper temperature followed by slow and uniform cooling. Proper instruments shall be provided for determining at all times the temperature of the bars.

246. Other steel which has been partially heated shall be properly annealed except where used in minor parts.

247. **Boring Pin Holes.** Pin holes shall be bored true to gage, smooth, straight, at right angles with the axis of the member and parallel with each other, unless otherwise required. The variation from the specified distance from outside to outside of pin holes in tension members, or from inside to inside of pin holes in compression members, shall not exceed $\frac{1}{32}$ in. In built-up members the boring shall be done after the member is riveted.

248. **Boring Pins.** Pins larger than 9 in. in diameter shall have a hole bored longitudinally through the center of each not less than 2 in. in diameter.

249. **Pin Clearances.** The difference in diameter between the pin and the pin hole shall be 1/50 in. for pins up to 5 in. in diameter, and $\frac{1}{32}$ in. for larger pins.

250. **Pins and Rollers.** Pins and rollers shall be accurately turned to gage and shall be straight, smooth and free from flaws.

251. **Screw Threads.** Screw threads shall make close fits in the nuts and shall be U. S. Standard, except that for pin ends of diameters greater than 1⅝ in. they shall be made with six threads to an inch.

252. **Welds.** Welds in steel not be allowed, except to remedy minor defects.

253. **Forging Pins.** Pins larger than 7 in. in diameter shall be forged and annealed.

254. **Bearing Surfaces Planed.** The top and the bottom surfaces of base and cap plates of columns and pedestals, except those in contact with masonry, shall be planed, or hot-straightened, and parts of members in contact with them shall be faced to fit. Connection angles for base plates and cap plates shall be riveted to compression members before the members are faced.

255. Sole plates of plate girders shall have full contact with the girder flanges. Sole plates and masonry plates shall be planed or hot-straightened. Cast pedestals shall be planed on the surfaces in contact with steel and shall have the bottom surfaces resting on masonry rough finished.

256. **Pilot Nuts.** Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified.

Weighing and Shipping

257. The payment for pound price contracts shall be based on the scale weight of the metal in the fabricated structure, including field rivets shipped. The weight of the field paint and cement, if furnished, boxes and barrels used for packing, and material used for staying or supporting members on cars, shall be excluded.

258. If the weight of any member is more than 2½ per cent less than the computed weight, it may be cause for rejection.

259. The greatest allowable variation of the total scale weight of any structure from the weights computed from the approved shop drawings shall be 1½ per cent. Any weight in excess of 1½ per cent above the computed weight shall not be paid for by the company.

260. **Computed Weight.** The weight of steel shall be assumed at 0.2833 lb. per cu. in.

261. The weights of rolled shapes, and of plates, up to and including 36 in. in width, shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts and open holes.

262. The weights of plates wider than 36 in. shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentages of overrun in weight given in Article 180.

263. The weight of heads of shop driven rivets shall be included in the computed weight.

264. The weights of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 10 per sent for fillets and overrun.

265. **Weighing of Members.** Finished work shall be weighed in the presence of the inspector, if practicable. The contractor shall furnish satisfactory scales and do the handling of the material for weighing.

266. **Marking and Shipping.** Members weighing more than 5 tons shall have the weight marked thereon. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, other small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 lb. A list and description of the contained material shall be plainly marked on the outside of each package, box or crate.

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267. Long girders shall be so loaded and marked that they may arrive at the bridge site in position for erection without turning.

268. Anchor bolts, washers and other anchorage or grillage materials shall be shipped in time for them to be built into the masonry.

Shop Painting

269. **Shop Cleaning and Painting.** Unless otherwise specified, steel work, after it has been accepted by the inspector and before leaving the shop, shall be thoroughly cleaned and given one coat of approved paint, applied in a workmanlike manner and well worked into joints and open spaces. Cleaning shall be done with steel brushes, hammers, scrapers and chisels, or by other equally effective means. Oil, paraffin and grease shall be removed by wiping with benzine or gasoline. Loose dirt shall be brushed off with a dry bristle brush before the paint is applied.

270. **Surfaces in Contact.** Surfaces coming in contact shall be cleaned and given one coat of paint on each surface before assembling.

271. **Erection Marks.** Erection marks shall be painted on painted surfaces.

272. **Painting in Damp or Freezing Weather.** Painting shall not be done in damp or freezing weather except under cover, and the steel must be free from moisture or frost when the paint is applied. Material painted under cover in damp or freezing weather shall be kept under cover until the paint is dry.

273. **Mixing of Paint.** Paint shall be thoroughly mixed before applying, and the pigments shall be kept in suspension.

274. **Machine Finished Surfaces.** Machine finished surfaces of steel (except abutting joints and base plates) shall be coated with white lead and tallow, applied hot as soon as the surfaces are finished and accepted by the Inspector.

Mill and Shop Inspection

275. Facilities for inspection of material and workmanship in the mill and shop shall be furnished by the contractor to the inspectors, and the inspector shall be allowed free access to the necessary parts of the premises.

276. **Mill Orders and Shipping Statements.** The contractor shall furnish the engineer with as many copies of material orders and shipping statements as the engineer may direct. The weights of the individual members shall be shown.

277. **Notice of Rolling.** The contractor shall give ample notice to the engineer of the beginning of rolling at the mill, and of work at the shop, so that inspection may be provided. No material shall be rolled nor work done before the engineer has been notified where the orders have been placed.

278. **Cost of Testing.** The contractor shall furnish, without charge, test specimens, as specified herein, and all labor, testing machines and tools necessary to make the specimen and full size tests.

279. **Inspector's Authority.** The inspector shall have the power to reject materials or workmanship which do not come up to the requirements of these specifications; but in cases of dispute, the contractors may appeal to the engineer, whose decision shall be final.

280. **Rejections.** The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective.

281. Rejected material and workmanship shall be replaced promptly or made good by the contractor.

282. **Full-Size Tests of Eye-Bars.** The number and size of the bars to be tested shall be stipulated by the engineer before the mill order is placed. The number shall not exceed 5 per cent of the whole number of bars ordered, with a minimum of two bars on small orders.

283. The test bars shall be the same section as the bars to be used in the structure and of the same length if within the capacity of the testing machine. They shall be selected by the inspector from the finished bars preferably after annealing. Test bars representing bars too long for the testing machine shall be selected from the full length bar material after the heads on one end have been formed and shall have the second head formed upon them after being cut to the greatest length which can be tested.

284. Full-size tests of eye-bars shall show a yield point of no less than 29,000 lb. per sq. in., an ultimate strength of not less than 54,000 lb. per sq. in., and an elongation of not less than 10 per cent in a length of 20 ft. measured in the body of the bar. The fracture shall show a silky or finely granular structure throughout.

285. If a bar fails to meet the requirements of paragraph 288, two additional bars of the same size and from the same mill heat shall be tested. If the failure of the first test bar is on account of the character of the fracture only, the bars represented by the test may be reannealed before the additional bars are tested.

286. If two of the three bars tested fail, the bars of that size and mill heat shall be rejected.

287. A failure in the head of a bar shall not be cause for rejection if the other requirements are fulfilled.

288. A record of the annealing charges shall be furnished the engineer showing the bars included in each charge and the treatment they receive.

289. Bars thus tested which meet the requirements of the specifications shall be paid for by the company at the same unit prices as the structures. Bars which fail to meet the requirements of the specifications, and all bars rejected as a result of tests, shall be at the contractor's expense.

A. R. E. A. Specifications for the Erection of Steel Bridges

1. **Work to Be Done.** The contractor shall erect, rivet and adjust all metal work in place complete, and perform all other work hereinafter specified.

2. **Plant.** The contractor shall provide all tools, machinery and appliances necessary for the expeditious handling of the work, including drift pins and fitting up bolts.

3. **Falsework.** The method of erection and plans for falsework and erection equipment shall be subject to approval by the engineer, but such approval shall not relieve the contractor from any responsibility. Falsework will be built by*.....
Falsework material of every character will be provided by the*.....

The temporary structure for use during erection and for maintaining the traffic shall be properly designed and substantially constructed for the loads which will come upon it. All bents shall be thoroughly secured against movement, both transversely and longitudinally. The bents shall be well secured against settling, and piles used wherever firm bottom cannot be obtained. Upon completion of the erection, the temporary structure, if the property of the railway company, shall be removed without unnecessary damage, and neatly piled near the site or loaded on cars, as may be directed. If the property of the contractor, it shall be removed in a manner subject to the approval of the engineer.

Falsework placed by the railway company under an old structure or for carrying traffic, may be used as far as practicable by the contractor during erection, but it shall not be unnecessarily cut or wasted.

4. **Conduct of Work.** The work shall be prosecuted with sufficient force, plant and equipment to expedite its completion to the utmost extent and in such a manner as to be at all times subordinate to the use of the tracks by the railway company, and so as not to interfere with the work of other contractors, or to close or obstruct any thoroughfare by land or water, except under proper authority.

Reasonable reduction of speed will be allowed upon request of the contractor. Tracks shall not be cut nor shall trains be subjected to any stoppage except when specifically authorized by the engineer. The contractor shall protect traffic and his work by flagmen furnished by and at the expense of the railway company. The contractor shall provide competent watchmen to guard the work and material against injury.

*Insert "railway company or "contractor," as the case may be.

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5. **Engine Service.** If under the contract, work train or engine service is furnished the contractor free of charge, such service shall consist only in unloading materials and in transferring the same from a convenient siding to the bridge site. Other engine service shall be paid for by the contractor at the rate of $..... per day per engine, the time to include the time necessary for the engine to come from and return to its terminal. When engine service is desired the contractor shall give the proper railway officials at least 24 hours' advance notice and the railway company will furnish the service as promptly as possible, consistent with railroad operations.

When derrick cars are used on main tracks, their movements shall be in charge of a train crew, and the expense of the crew and any engine service other than as noted above shall be charged to the contractor.

6. **Transportation.** When transportation of equipment, materials and men is furnished free over the railway company's line, it shall be subject to such conditions as may be stated in the contract.

7. **Masonry.** The railway company will furnish all masonry to correct lines and elevations, and unless otherwise stated in the contract, will make all changes in old masonry without unnecessarily impeding the operations of the contractor. The railway company's engineer will establish lines and elevations and assume responsibility therefor, but the contractor shall compare the elevations, distances, etc., shown on plans, with the masonry as actually constructed as far as practicable, before he assembles the steel. In case of discrepancy, he shall immediately notify the engineer.

8. **Handling and Storing of Materials.** Cars containing materials or plant shall be promptly unloaded upon delivery therefor, and in case of failure to do so the contractor shall be liable for demurrage charges. Material shall be placed on skids above the ground, laid so as not to hold water, and stored and handled in such a manner as not to be injured or to interfere with railroad operations. The expense of repairing or replacing material damaged by rough handling shall be charged to the contractor. The contractor, while unloading and storing material, shall compare each piece with the shipping list and promptly report any shortage or injury discovered.

9. **Maintenance of Traffic.** When traffic is to be maintained it will be carried on in such a manner as to interfere as little as practicable with the work of the contractor.

Changes in the supporting structure or tracks required during erection shall be at all times under the direct control and supervision of the railway company.

10. **Removal of Old Structure.** Unless otherwise specified, metal work in the old structure shall be dismantled without unnecessary damage and loaded on cars or neatly piled at a site immediately adjacent to the tracks, and at a convenient grade for future handling, as may be directed. When the structure is to be used elsewhere all parts will be match-marked by the railway company; when the old bridge is composed of several spans the parts of each shall be kept separate.

11. **Metal Work.** Material shall be handled without damage. Threads of all pins shall be protected by pilot and driving nuts while being driven in place.

Light drifting will be permitted in order to draw the parts together, but drifting for the purpose of matching unfair holes will not be permitted. Unfair holes shall be reamed or drilled.

Nuts on pins and on bolts remaining in the structure shall be effectively locked by checking the threads.

All splices and field connections shall be securely bolted prior to riveting. When the parts are required to carry traffic, important connections, such as attachments of stringers and floor beams, shall have at least 50 per cent of the holes filled with bolts and 25 per cent with drift pins. All tension splices shall be riveted up complete before blocking is removed. When not carrying traffic, at least 33⅓ per cent of the holes shall have bolts.

Rivets in splices of compression members shall not be driven until the members shall have been subjected to full dead load stresses. Rivets shall be driven tight. No recupping or calking will be permitted. The heads shall be full and uniform in size and free from fins, concentric and in full contact with the metal. Heads shall be painted immediately after acceptance.

Rivets shall be uniformly and thoroughly heated and no burnt rivets shall be driven. All defective rivets shall be promptly cut out and redriven. In removing rivets the surrounding metal shall not be injured; if necessary, the rivets shall be drilled out.

12. **Misfits.** Correction of minor misfits and a reasonable amount of reaming shall be considered as a legitimate part of the erection.

Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, and a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the engineer and the work of correction done in the presence of the engineer, who shall check the time expended. The contractor shall render an itemized bill for such work of correction for the approval of the engineer.

13. **Anchor Bolts.** Holes for all anchor bolts, except where bolts are built up with the masonry, shall be drilled by the contractor after the metal is in place and the bolts shall be set in Portland cement grout.

14. **Bed Plates.** Bed plates resting on masonry shall be set level and have a full, even bearing over their entire surface; this shall be attained by either the use of Portland cement grout or mortar, or by tightly ramming in rust cement under the bed plates after blocking them accurately in position.

15. **Decks.** The *.....will frame and place the permanent timber deck.

16. **Painting.** The paint will be furnished by *..... ....., and shall be of such color, quality and manufacture as may be specified.

Surfaces inaccessible after erection, such as bottoms of base plates, tops of stringers, etc., shall receive two coats of paint before assembling in place. After erection, the entire structure shall receive two coats of paint, allowing enough time between coats for the first coat to dry before applying the second. No paint shall be applied in wet or freezing weather, nor when the surface of the metal is damp. Painting shall be done in good and workmanlike manner, subject to strict instructions which shall be given by the engineer. All metal shall be thoroughly cleaned of dirt, rust, loose scale, etc., before the paint is applied.

17. **Clearing the Site.** The contractor, after completion of the work of erection, shall remove all old material and debris resulting from his operations and place the premises in a neat condition.

18. **Superintendence of Workmen.** During the entire progress of the work the contractor shall have a competent superintendent in personal charge and shall employ only skilled and competent workmen. Instructions given by the engineer to the superintendent shall be carried out the same as if given to the contractor. If any of the contractor's employees by unseemly or boisterous conduct, or by incompetency or dishonesty, show unfitness for employment on the work, they shall, upon instructions from the engineer, be discharged from the work, nor thereafter be employed upon it without the engineer's consent.

19. **Inspection.** The work of erection shall at all times be subject to the inspection and acceptance of the engineer.

20. The term "Engineer," as used herein, shall be understood to mean the Chief Engineer of the Railway Company, or his accredited representative.

*Insert "railway company" or "contractor," as the case may be.

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- **BRIDGE, MOVABLE.** A special type of bridge designed to be readily moved from and returned to its normal position to permit the unobstructed passage of vessels, etc. See Bridge.

BRIDGE PIER. One of the intermediate supports of a bridge, usually a columnar structure of masonry oblong in section which transmits the loads from the superstructure to the foundation. A pier supports the abutting ends of two adjacent spans, whereas an abutment supports the end of the bridge. The location of piers is a consideration which frequently influences the design of the bridge, for they must not obstruct water traffic and must be placed on unquestionable foundations, deep enough to avoid water scour and frost. They are commonly built with the aid of coffer dams or open caissons where the foundation work is well below water level, some form of pneumatic caisson being used for depths greater than about 40 ft. Pile foundations are used up to this depth when there is a suitable amount of loose material overlying the rock.

Pile Bridge Pier

Piers are sometimes made of wooden piles driven close together, a group of 40 or more being enclosed with sheathing after which rip rap stone is dumped within the enclosure around the piles which are cut off and capped to receive the superstructure. Stone masonry piers, boat shaped in plan have been largely used and the design has influenced the names of parts, some of which have survived in concrete designs. Thus the coping protects the pier from the weather; the belting course next below, strengthens the coping; the footing course or portion of the pier extends the distribution of the loads; and the starling or cutwater divides the current with a minimum disturbance, thereby protecting the pier from eddies and consequent scour.

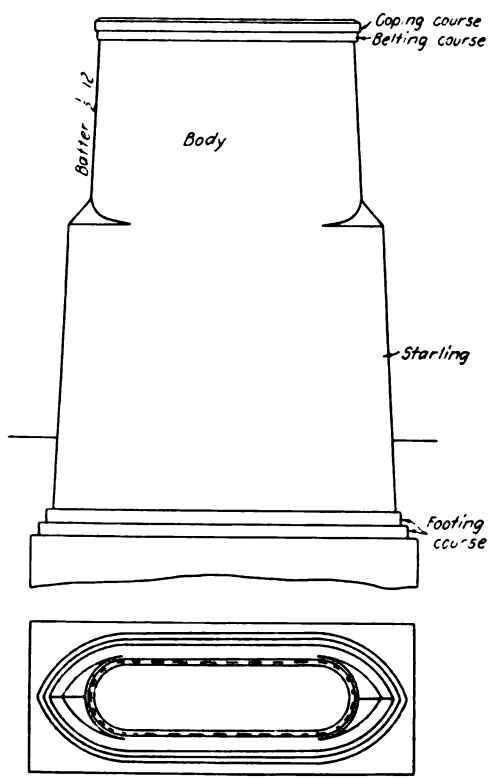
The purpose of a pier is to transmit the loads from the superstructure to the foundation, at the same time presenting the least possible obstacle to the natural flow of the water. A pier usually has an oblong or rectangular body with a triangular upstream end or with symmetrical triangular or rounded ends, the symmetrical form having the advantage of equality in distribution of pressure on the foundation.

Another form, the cylindrical, admits of several variations, ranging from the pivot type for swing span, to the multiple cylinder structure for tower spans, the common variety being the two cylinder pier for fixed spans with the tubes placed side by side beneath the truss or girder bearings and usually connected by a cross frame or diaphram to increase their stability. These cylinders are usually made of steel plates ¼ in. to ½ in. thick, riveted in sections convenient for handling, about 6 ft. to 10 ft. in diameter and 10 to 16 ft. long. They are sunk to the desired foundation as the soft material is excavated from the tube by an orange peel or clam shell bucket after which it is replaced by concrete.

Frequently piles are driven inside the tube after the completion of the excavation, the tops of the piles extending up into the cylinder and being embedded in the concrete with which the tube is filled. A pivot pier may consist of one large cylinder or of a central tube and a circle of outside tubes.

Rectangular Body Piers

This type of pier is made (1) of solid masonry or (2) hollow. The solid masonry pier sometimes contains some unnecessary mass between the load points near the top, the pier acting to a certain extent as a double column structure, the portion directly beneath a pedestal carrying its load as a separate column, while the mass between the columns braces the structure and tends to minimize vibration.



Sketch of Concrete Bridge Pier Showing Parts

Solid piers of stone masonry have facing courses of ashlar with backing of rubble, sometimes with coursed joints. Some solid piers have ashlar facings and concrete backing. Concrete piers are favored because of their comparative cheapness. Reinforcement is not usually required in the body of a solid concrete pier, although I-beam grillages on top to distribute the loads over the entire surface may be necessary in certain cases. Reinforcement to protect the nosings are often resorted to, especially the upstream apex angle which must resist contact with debris and ice. The hollow pier, usually of rein-

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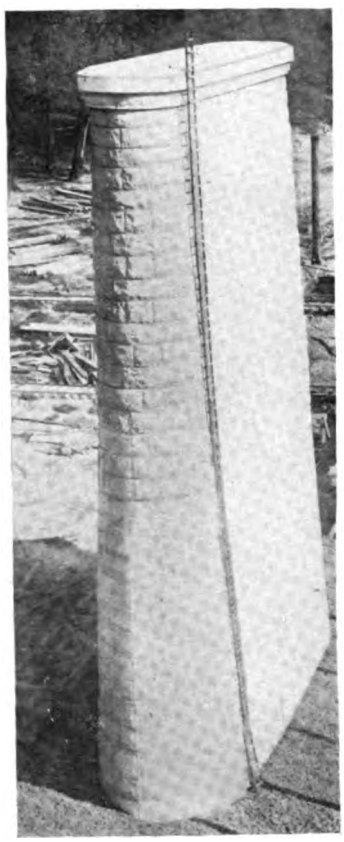
forced concrete, is a compromise between the cylindrical type and the solid pier, being more stable than the former and may be more economical than the latter. The side walls of rectangular body piers are commonly battered 1 in. in 24 in. vertical while the starling noses are set at angles dependent on the force of the current and the amount of ice and debris expected. Many nosings are set at angles of 45 deg. from the vertical. In other cases the starling takes the same batter as the side walls, and an offset of several feet at each end above the starling coping affords an opportunity to make the pier rectangular in section above the high water line. Some rectangular body piers have hollow chambers in this upper portion while others are arched or double arched between load points.

Cylinder Piers

The so-called cylinder pier is commonly a tall slender tube or a number of tubes, although tubes oblong in horizontal section are sometimes used. The sections are handled with a derrick, wooden frames being put in the tube to hold it in shape until it is erected. The cylinder must be placed accurately and sunk carefully to land it in the correct position for the superstructure. A cylinder may sometimes be sunk by cribbing from its top up to the existing bridge deck and using the weight of a locomotive on the bridge to press the cylinder down. Excavation is carried on inside the tube, usually by hand to water level and to deeper levels with a grab bucket, a small orange peel being the type commonly used.

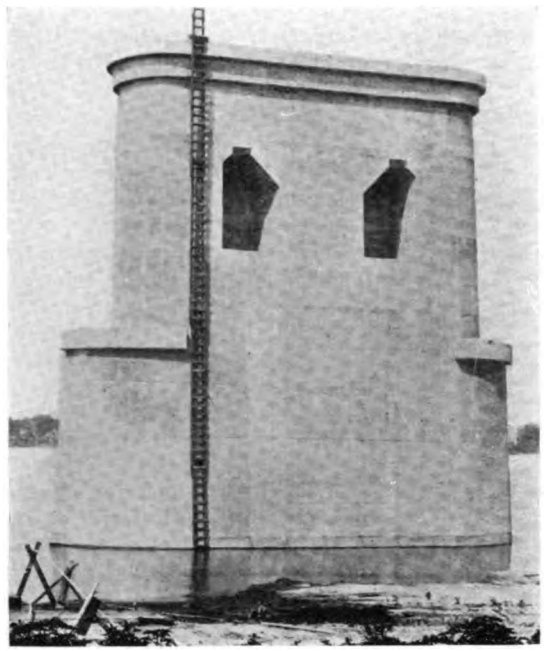


Bridge Pier of Stone Masonry

Where the bottom is soft, the cylinders are weighted and sunk to hard ground, the soft material is excavated and piles are driven inside the tubes. It is not usually feasible to cut piles off inside a cylinder nor to tamp concrete about piles. Therefore a test pile preferably is driven to extend a few feet above the bottom of the cylinder which is sealed with concrete, after which the water is pumped out and the remainder of the concrete is poured and tamped in the usual way.

It is frequently found necessary to place rip rap around the bottom of the tube to prevent scouring, especially when the pier is placed in a current. A crib built around the tube or pier and filled with rip rap is a common form of protection. Where the foundations are solid rock the cylinders are usually held in place by anchor bolts or dowels.

In shallow water a coffer-dam may be built around the pier so that the rock can be leveled off and holes drilled for anchor bolts which are placed to extend up several feet into the cylinders, the concrete being deposited around them. If the rock foundation is uneven and it is impossible to level it off, the bottom of the tubing may be cut to fit the irregularities.



Concrete Pier

BRIDGE SEAT. A horizontal surface on a pier, or an abutment, to support the base plates or pedestals bearing the end of the bridge span. See Bridge Pier. Also Abutment, Bridge.

BRIDGE, SKEW. A bridge which crosses a passageway at other than a right angle, necessitating the placing of its supports at acute angles to the center line, usually to place them parallel with the passageway and its current if any, thus minimizing the widths of the obstructed portions of the passageway and the areas of bridge supports facing the current. See Bridge Pier.

BRIDGE, SUSPENSION. A bridge in which the deck is supported by cables suspended between piers at the ends of the structure.

The distinctive features of this type are (1) a pair of piers at each end of the bridge, high enough to support the cables so that at the middle of the span they will be at the desired elevation in relation to the deck, (2) rods depending from the main cables to support the level deck and (3) stiffening trusses. etc., designed to minimize excessive deflection under concentrated loads.

The eye-bar chains or wire cables, commonly called main cables, usually rest on saddles carried by rollers on or near the tops of the piers from which their ends are drawn back, down and beyond the bridge ends to masonry anchorages to which they

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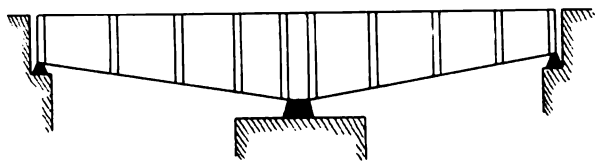
are secured. While economically adaptable to very long spans, suspension bridges are not often used for railways because even when supplied with stiffeners their flexibility is much greater than that of other types. See Bridge.

BRIDGE, SWING. A movable bridge designed to revolve horizontally on a pivot pier to permit the passage of vessels too high to pass beneath a fixed span at the desired height above the water. A swing bridge is usually built across a waterway navigable for large vessels, being supported and revolving on a pivot pier in the middle of the channel. A swing span may extend from abutment to abutment over a small stream or it may be located over the channel of a wide stream spanned by a long bridge with a number of fixed spans at each end of the movable span, which is designed to rest when closed on the piers supporting the fixed spans. It usually consists of two through trusses which support the floor system and are themselves supported and balanced on the pivot pier bearing the turning machinery so that the span revolves on a nest of radial rollers, or a circle of small wheels each at the end of a radial axle and rolling on a pivot-encircling monorail or tread.

Center-bearing spans have trusses supported on loading girders which carry the dead load of the bridge to the center pivot on the pier about which the span revolves. A number of trailing wheels varying from 8 to 20 in. in diameter placed under the turntable and traveling in a circle on the center pier, steady the bridge while swinging, but otherwise receive no load.

The trusses of a rim-bearing span are ordinarily supported directly on a drum or on load-distributing girders from which the weight is carried to a circular girder or drum which rests on conical wheels which in turn are supported on a circular track on the pivot pier and support the entire load of the structure when the bridge is open. In heavy swing spans a combination of the center and rim bearings is generally used so that the greater part of the weight is carried on a turntable and the lesser part on the central pivot which tends to hold the pivot in place and prevent the drum from becoming distorted. Electric, steam or gasoline power units, connected by means of gears to a vertical shaft attached to the drum of a rim-bearing turn-table or to the girders of floor beams of the center-bearing type, are employed to revolve swing bridges. A pinion placed on the lower end of the vertical shaft engages the teeth of the circular rack on the pivot pier or the lower track on which the turntable revolves.

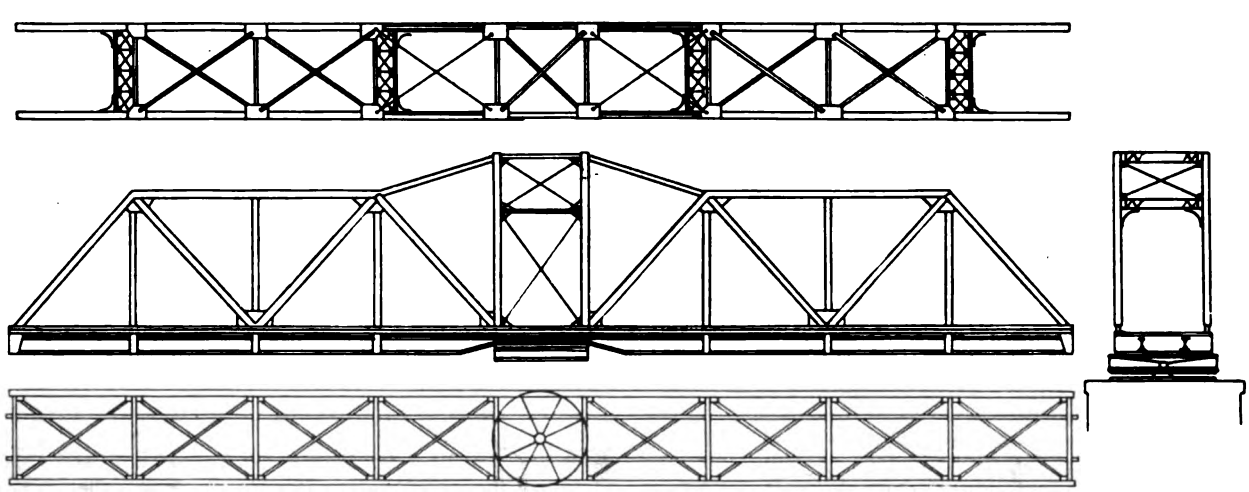
Swing spans generally have some form of end-lifting devices designed to lift the ends of the trusses



Sketch of a Deck Girder Swing Bridge

when the bridge closes and to release them when the span is to be opened. The lifting is sometimes accomplished by allowing the ends of the trusses to run up on wheels which are mounted on the fixed substructures, other devices such as toggles or hydraulic jacks or wedges being used in large structures to raise the ends of the closing span enough to take out part of the cantilever deflection and transfer a part of the load to the end piers. End-locks are commonly provided as a means of centering and holding the ends of the span while rail-locks are used to hold the ends of the movable span running rails in line with those of the adjacent fixed spans. The locks are generally arranged to open automatically before the bridge swings from the supports and to close after it is again in place, operating in connection with automatic signals and derails interlocked with them.

Swing spans are protected from damage by vessels by fender piling and masonry or stone-filled timber cribs built around the pivot pier and extending lengthwise to the limits of the swing span in the open position. Government regulations provide that day and night signals shall be maintained at all times for the information of vessels plying a navigable stream spanned by movable bridges. See Bridge.



Sketch of a Through Truss Swing Bridge

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BRIDGE, TIMBER. A bridge made of wood, usually of sawn timbers framed together and held by means of the framing and by metal fastenings and placed on piles or other foundations.

Timber bridges may be built in any design but the material is most suitable for trestle spans of 15 ft. and under. While timber trusses are still built, the only type in frequent use for new structures is the Howe truss which is a satisfactory bridge requiring however, skillful framing by artisans experienced in this design. Bridge timber is preferably treated with a wood preservative.

Specifications for bridge timber, for wooden piles, for metal details and for workmanship on timber bridges, and principles of practise in driving wooden piles, as well as a table of working stresses for timber used in bridges and trestles as adopted by the A. R. E. A. follow:

Standard Specifications for Southern Yellow Pine Bridge and Trestle Timbers

(To be applied to single sticks and not to composite members.)

1. **General Requirements.** Except as noted, all timber shall be sound, sawed to standard size, full length, square cornered and straight; close grained and free from defects such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay, or other defects that will materially impair its strength.

2. **Standard Size.** "Rough timbers sawed to standard size" means that they shall not be over ¼ in. scant from the actual size specified. For instance, a 12-in. by 12-in. timber shall measure not less than 11¾ in. by 11¾ in.

3. "Standard dressing" means that not more than ¼ in. shall be allowed for dressing each surface. For instance a 12-in. by 12-in. timber, after being dressed on four sides, shall measure not less than 11½ in. by 11½ in.

Standard Heart Grade Longleaf Yellow Pine

4. Stringers shall show not less than 85 per cent heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer, the average depth of sap shall not exceed one-half inch. Knots greater than 1½ in. in diameter will not be permitted at any section within 4 in. of the edge of the piece, but knots shall in no case exceed 4 in. in their largest diameter.

5. Caps and sills shall show not less than 85 per cent heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots over 2½ in. in diameter.

6. Posts shall show not less than 75 per cent heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots over 2½ in. in diameter.

7. Longitudinal struts and girts shall be square cornered and sound. One side shall show all heart; the other side shall show not less than 85 per cent heart, measured across the side anywhere in the length of the piece, and shall be free from any large knots or other defects that will materially injure their strength.

8. Longitudinal X braces, sash braces and sway braces shall be square cornered and sound; shall show not less than 80 per cent heart on each of the two sides, and shall be free from any large knots or other defects that will materially injure their strength.

9. Ties and guard rails shall show one side all heart; the other side and two edges shall show not less than 75 per cent heart, measured across the surface anywhere in the length of the piece; shall be free from any large knots or other defects that will materially injure their strength; and where surfaced the remaining rough face shall show all heart.

Standard Grade, Longleaf and Shortleaf Yellow Pine

10. Stringers shall be square cornered, with the exception of 1 in. wane on one corner or ½ in. wane on two corners. Knots shall not exceed in their largest diameter ¼ of the width of the surface of the stick in which they occur, and shall in no case exceed 4 in. Ring shakes shall not extend over ⅛ of the length of the piece.

11. Caps and sills shall be square cornered, with the exception of 1 in. wane on one corner, or ½ in. wane on two corners. Knots shall not exceed in their longest diameter ¼ of the width of the surface of the stick in which they occur, and in no case shall exceed 4 in. Ring shakes shall not extend over ⅛ of the length of the piece.

12. Posts shall be square cornered, with the exception of 1 in. wane on one corner, or ½ in. wane on two corners. Knots shall not exceed, in their longest diameter ¼ of the width of the surface of the stick in which they occur, and shall in no case exceed 4 in. Ring shakes shall not extend over ⅛ of the length of the piece.

Explanatory Note for Standard Heart Grade

These specifications state the maximum limit of sapwood which will be accepted. In practice, with good inspection, the effect of these specifications should be to secure timber the bulk of which is practically all heart. In permanent bridge timber, not protected from decay, sapwood is not only useless in itself, but by furnishing a lodgment for the spores of fungi, it is the cause of starting and promoting the continuance of rot in the heart. Sapwood, especially after decay has set in, is also extremely susceptible to fire, while with precautions ordinarily exercised heartwood is practically immune from this source of danger.

On the other hand, for ordinary commercial purposes sapwood is as valuable as heart. Therefore, if the mill owners understand what is wanted, good heart timber can be obtained for a small advance in price over what is usually furnished, much of which contains in bulk 50 per cent or more of sapwood.

To obtain proper results, inspection should be made at the mills, where unsatisfactory timber can be rejected without hardship to the mill owner. Extensive buyers of timber should have inspectors stationed at the mills. To cover the needs of smaller buyers and municipalities, it seems that some of the established inspection companies might maintain an organization of timber inspectors at the mills, which would prove profitable to themselves, satisfactory to the mill owners and of incalculable benefit to those who use the timber.

Standard Specifications for Douglas Fir and Western Hemlock Bridge and Trestle Timbers

(To be applied to single sticks and not to composite members.)

Standard Heart Grade

1. Standard heart grade shall include yellow and red Douglas fir and western hemlock. White Douglas fir will not be accepted.

2. **General Requirements.** All timber shall be live, sound, straight and close grained, cut square cornered, full length, not more than ¼ in. scant in any dimension for rough timber or ½ in. for dressed timber; free from large, loose or unsound knots, knots in groups, or other defects that will materially impair its strength for the purpose for which it is intended, and subject to inspection before loading.

3. Stringers shall show not less than 90 per cent heart on each side and edge, measured across the surface anywhere in the length of the piece. Stringers shall be out of wind and free from shakes, splits, or pitch pockets over ⅜ in. wide or 5 in. long. Knots

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greater than 2 in. in diameter will not be permitted within ¼ of the depth of the stringer from any corner nor upon the edge of any piece. Knots shall in no case exceed 3 in. in diameter.

4. Caps, sills and posts shall show not less than 85 per cent heart on each of the four sides, measured across the surface anywhere in the length of the piece; which shall be out of wind and free from shakes, splits, or pitch pockets over ½ in. wide or 5 in. long. Knots shall not exceed ¼ of the width of the surface of the piece in which they occur and shall in no case exceed 3 in. in diameter.

5. Longitudinal struts or girts, X braces, sash and sway braces shall show one side all heart. The other side and two edges shall show not less than 85 per cent heart, measured across the surface anywhere in the length of the piece.

6. Ties and bond timbers shall show one side and one edge all heart. The other side and edge shall show not less than 85 per cent heart, measured across the surface anywhere in the length of the piece.

7. Timbers for Howe truss chords shall show not less than 90 per cent heart on each side and edge, measured anywhere in the length of the piece. They shall be out of wind and free from shakes, splits, or pitch pockets over ⅛ in. wide or 3 in. long. Knots shall not be over 1½ in. in diameter nor be closer together on each surface than one in any 4 linear feet; but if knots are 1 in. or less in diameter, one knot in any 3 linear feet will be allowed.

8. Standard grade shall include yellow, red and white Douglas fir and western hemlock.

9. **General Requirements.** All timbers shall be sound and cut square cornered, except that timbers 10 in. by 10 in. in size may have 2-in. wane on one corner or its equivalent on two or more corners. Other sizes may have proportionate defects. Must be free from defects which will impair its utility for temporary work. Knots shall not exceed ¼ the width of the surface of the piece in which they occur. Timber must be subject to inspection before loading.

10. Stringers, caps, sills and posts shall be out of wind, free from shakes or splits extending over more than ⅛ of the length of the piece, or knots more than 4 in. in diameter. Knots greater than 3 in. in diameter will not be permitted on the edge of any stringer.

A. R. E. A. Specifications for Timber Piles
Railroad Heart Grade

1. This grade includes white, burr, and post oak; longleaf pine, Douglas fir, tamarack, eastern white and red cedar, chestnut, western cedar, redwood and cypress.

2. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knits, decay or other defects, which may materially impair their strength or durability. In eastern red or white cedar a small amount of heart rot at the butt, which does not materially injure the strength of the pile, will be allowed.

3. Piles must be butt cut above the ground swell and have a uniform taper from butt to tip. Short bends will not be allowed. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile.

4. Unless otherwise allowed, piles must be cut when sap is down. Piles must be peeled soon after cutting. All knots shall be trimmed close to the body of the pile.

5. The minimum diameter at the tips of round piles shall be 9 in. for lengths not exceeding 30 ft.; 8 in. for lengths over 30 ft. but not exceeding 50 ft., and 7 in. for lengths over 50 ft. The minimum diameter at ¼ of the length from the butt shall be 12 in. and the maximum diameter at the butt 20 in.

6. The minimum width of any side of the tip of a square pile shall be 9 in. for lengths not exceeding 30 ft.; 8 in. for lengths over 30 ft. but not exceeding 50 ft., and 7 in. for lengths over 50 ft. The minimum width of any side at ¼ of the length from the butt shall be 12 in.

7. Square piles shall show at least 80 per cent heart on each side at any cross-section of the stick and all round piles shall show at least 10½ in. diameter of heart at butt.

Railroad Falsework Grade

8. This grade includes red and all other oaks not included in railroad heart grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine or any sound timber that will stand driving.

9. The requirements for size of tip and butt taper and lateral curvature are the same as for railroad heart grade.

10. Unless otherwise specified piles need not be peeled.

11. No limits are specified as to the diameter or proportion of heart.

12. Piles which meet the requirements of railroad heart grade except the proportion of heart specified will be classed as railroad falsework grade.

A. R. E. A. Specifications for Metal Details Used in Wooden Bridges and Trestles

1. Wrought-iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1 or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lb. per sq. in., an elongation of 18 per cent in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 deg. without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent fibrous.

2. Steel shall be made by the open-hearth process and shall be of uniform quality. It shall contain not more than 0.05 per cent sulphur. If made by the acid process it shall contain not more than 0.06 per cent phosphorous; and if made by the basic process, not more than 0.04 per cent phosphorus. When tested in specimens of the form of Fig. 1, or full-sized pieces

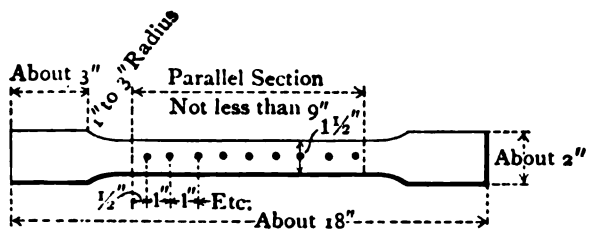

Fig. 1.

of the same length, it shall have a desired ultimate tensile strength of 60,000 lb. per sq. in. If the ultimate strength varies more than 4000 lb. from that desired, a retest shall be made on the same gage, which, to be acceptable, shall be within 5000 lb. of the desired ultimate. It shall have a minimum percentage of elongation in 8 in. of $\frac{1{,}500{,}000}{\text{ultimate tensile strength}}$ and shall bend cold without fracture 180 deg. flat. The fracture for tensile tests shall be silky.

3. **Cast-Iron.** Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "arbitration bar" of the American Society for Testing Materials, which is a round bar 1¼ in. in diameter and 15 in. long. The transverse test shall be made on a supported length of 12 in., with load at middle. The minimum breaking load so applied shall be 2900 lb., with a deflection of at least 1/10 in. before rupture.

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4. Bolts shall be of wrought-iron or steel, made with square heads, standard size, the length of thread to be 2½ times the diameter of bolt. The nuts shall be made square, standard size, with thread fitting closely the thread of bolt. Threads shall be cut according to U. S. standards.

5. Drift bolts shall be of wrought-iron or steel, with or without square head, pointed or without point, as may be called for on plans.

6. Spikes shall be of wrought-iron or steel, square or round, as called for on the plans. Steel wire spikes, when used for spiking planking, shall not be used in lengths more than 6 in.; if greater lengths are required, wrought or steel spikes shall be used.

7. Packing spools or separators shall be of cast-iron, made to size and shape called for on plans. The diameter of hole shall be ⅛ in. larger than diameter of packing bolts.

8. Cast washers shall be of cast-iron. The diameter shall be not less than 3½ times the diameter of bolt for which it is used, and its thickness equal to the diameter of bolt. The diameter of hole shall be ⅛ in. larger than the diameter of the bolt.

9. Wrought washers shall be of wrought-iron or steel, the diameter shall be not less than 3½ times the diameter of bolt for which it is used, and not less than ¼ in. thick. The hole shall be ⅛ in. larger than the diameter of the bolt.

10. Special castings shall be made true to pattern, without wind, free from flaws and excessive shrinkage; size and shape to be as called for by the plans.

Specifications for Workmanship for Pile and Frame Trestles to Be Built Under Contract

1. **Site.** The trestle to be built under these specifications is located on the line of.....Railway at ....., County of..... State of.....

2. **General Description.** The work to be done under these specifications covers the driving, framing and erection of a ..... track wooden trestle about ..... ft. long and an average of ..... ft. high.

3. **General Clauses.** The contractor shall furnish all necessary labor, tools, machinery, supplies, temporary staging and outfit required. He shall build the complete trestle ready for the track rails, in a workmanlike manner, in strict accordance with the plans and the true intent of these specifications, to the satisfaction and acceptance of the engineer of the railway company.

4. The workmanship shall be of the best quality in each class of work. Details, fastenings and connections shall be of the best method of construction in general use on first-class work.

5. Holes shall be bored for all bolts. The depth of the hole and the diameter of the augur shall be as specified by the engineer.

6. Framing shall be accurately fitted. No blocking or shimming will be allowed in making joints. Timbers shall be cut off with the saw; no axe to be used.

7. Joints and points of bearing, for which no fastening is shown on the plans, shall be fastened as specified by the engineer.

8. The engineer or his authorized agents shall have full power to cause any inferior work to be condemned, and taken down or altered, at the expense of the contractor. Any material destroyed by the contractor on account of inferior workmanship or carelessness of his men must be replaced by the contractor at his own expense.

9. Figures shown on the plans shall govern in preference to scale measurements. If any discrepancies should arise or irregularities be discovered in the plans, the contractor shall call on the engineer for instructions. These specifications and the plans are intended to coincide, and if any question arises as to the proper interpretation of the plans or specifications, it shall be referred to the engineer for a ruling.

10. The contractor shall, when required by the engineer, furnish a satisfactory watchman to guard the work.

11. On the completion of the work, all refuse material and rubbish that may have accumulated on top and under and near the trestle, by reason of its construction, shall be removed by the contractor.

12. **Detail Specifications.** Piles shall be carefully selected to suit the place and ground where they are to be driven. When required by the engineer, pile butts shall be banded with iron or steel for driving, and the tips shod with suitable iron or steel shoes. Such shoes will be furnished by the railway company.

13. Piles shall be driven to firm bearing, satisfactory to the engineer; or until five blows of a hammer weighing 3000 lb. falling 15 ft. (or a hammer and fall producing the same mechanical effect), are required to cause an average penetration of ½ in. per blow, except in soft bottom, where special instructions will be given.

14. Batter piles shall be driven to the inclination shown by the plans, and shall require but slight bending before framing.

15. Butts of all piles in a bent shall be sawed off to one plane and trimmed so as not to leave any horizontal projection outside of the cap.

16. Piles injured in driving, or driven out of place, shall either be pulled out or cut off, and replaced by new piles.

17. Caps shall be sized over the piles or posts to a uniform thickness and even bearing on piles or posts. The side with most sap shall be placed downward.

18. Posts shall be sawed to proper length for their position (vertical or batter), and to even bearing on cap and sill.

19. Sills shall be sized at the bearing of posts to one plane.

20. Sway bracing shall be properly framed and securely fastened to piles or posts. When necessary, filling pieces shall be used between the braces and the piles of a bent on account of the variation in size of piles, and securely fastened and faced to obtain a bearing against all piles.

21. Longitudinal X braces shall be properly framed and securely fastened to piles or posts.

22. Girts shall be properly framed and securely fastened to caps, sub-sills, posts or piles, as the plans may require.

23. Stringers shall be sized to a uniform height at supports. The edges with most sap shall be placed downward.

24. Jack stringers, if required on the plans, shall be neatly framed on caps, and their tops shall be in the same plane as the track stringers.

25. Ties shall be framed to a uniform thickness over bearings, and shall be placed with the rough side upward. They shall be spaced regularly and cut to even length and line, as called for on the plans.

26. Timber guard rails shall be framed as called for on the plans, laid to line and to a uniform top surface. They shall be firmly fastened to the ties as required.

27. Bulkheads shall be of sufficient dimensions to keep the embankment clear of the caps, stringers and ties, at the end bents of the trestle. There shall be a space of not less than 2 in. between the back of the end bent and the face of the bulkhead. The projecting ends of the bulkhead shall be sawed off to conform to the slope of the embankment unless otherwise specified.

28. **Time of Completion.** The work shall be completed in all its parts on or before..... ..... 19.....

29. Payments will be made under the usual regulations of the railway company.

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PILE DRIVING—A. R. E. A. PRINCIPLES OF PRACTICE

1. A thorough exploration of the soil by borings, or preliminary test piles, is the most important prerequisite to the design and construction of pile foundations.

2. Soil consisting wholly or chiefly of sand is most favorable to the use of the water jet.

3. In harder soils containing gravel the use of the jet may be advantageous, if sufficient volume and pressure be provided.

4. In clay it may be economical to bore several holes in the soil with the aid of the pet before driving the pile, thus securing the accurate location of the pile, and its lubrication while being driven.

5. In general, the water jet should not be attached to the pile, but handled separately.

6. Two jets will often succeed where one fails. In special cases a third jet extending a part of the depth aids materially in keeping loose the material around the pile.

7. Where the material is of such a porous character that the water from the jets may be dissipated and fail to come up in the immediate vicinity of the pile, the utility of the jet is uncertain, except for a part of the penetration.

8. A steam or drop hammer should be used in connection with the water jet, and used to test the final rate of penetration.

9. The use of the water jet is one of the most effective means of avoiding injury to piles by overdriving.

10. There is danger from overdriving when the hammer begins to bounce. Overdriving is also indicated by the bending, kicking or staggering of the pile.

11. The brooming of the head of the pile dissipates a part, and in some cases all, of the energy due to the fall of the hammer.

12. The steam hammer is usually more effective than the drop hammer in securing the penetration of a wooden pile without injury, because of the shorter interval between blows.

13. Where shock to surrounding material is apt to prove detrimental to the structure, the steam hammer should always be used instead of the drop hammer. This is especially true in the case of sheet piling which is intended to prevent the passage of water. In some cases also the jet should not be used.

14. In general, the resistance of piles, penetrating soft material, depending solely upon skin friction, is materially increased after a period of rest. This period may be as short as fifteen minutes, and rarely exceeds twelve hours.

15. Where a pile penetrates muck or a soft yielding material and bears upon a hard stratum at its foot, its strength should be determined as a column or beam; omitting the resistance, if any, due to skin friction.

16. Unless the record of previous experience at the same site is available, the approximate bearing power may be obtained by loading test piles. The results of loading test piles should be used with caution, unless their condition is fairly comparable with that of the piles in the proposed foundation.

17. In case the piles in a foundation are expected to act as columns, the results of loading test piles should not be depended upon unless they are sufficient in number to insure their action in a similar manner; and unless they are stayed against lateral motion.

18. Before testing the penetration of a pile in soft material where its bearing power depends principally, or wholly, upon skin friction, the pile should be allowed to rest for 24 hours after driving.

19. Where the resistance of piles depends mainly upon skin friction, it is possible to diminish the combined strength, or bearing capacity, of a group of piles by driving additional piles within the same area.

20. Where piles will foot in a hard stratum, investigation should be made to determine that this stratum is of sufficient depth and strength to carry the load.

21. Timber piles may be advantageously pointed, in some cases, to a 4-in. or 6-in. square at the end.

22. Piles should not be pointed when driven into soft material.

23. Shoes should be provided for piles when the driving is very hard, especially in riprap or shale. These shoes should be so constructed as to form an integral part of the pile.

24. The use of a cap is advantageous in distributing the impact of the hammer more uniformly over the head of the pile, as well as in holding it in position during driving.

BRIDGE, VERTICAL LIFT. A movable bridge span designed to be elevated in a vertical plane without tilting the floor to permit the passage of vessels, etc., under it.

This type of structure is usually installed at skew crossings where bascule spans are not readily used. It generally consists of a simple truss span over a channel, with fixed approach spans at each end.

WORKING UNIT-STRESSES FOR STRUCTURAL TIMBER EXPRESSED IN POUNDS PER SQUARE INCH (A.R.E.A.)

KIND OF TIMBER	BENDING			SHEARING				COMPRESSION						Ration of Length of Stringer to Depth.
	Extreme Fiber Stress		Modulus of Elasticity	Parallel to the Grain		Longitudinal Shear in Beams		Perpendicular to the Grain		Parallel to the Grain		For Columns Under 15 Diams. Working Stress.	Formulas for Working Stress in Long Columns Over 15 Diameters.	
	Average Ultimate	Working Stress	Average	Average Ultimate	Working Stress	Average Ultimate	Working Stress	Elastic Limit	Working Stress	Average Ultimate	Working Stress			
Douglas Fir	6100	1200	1 510 000	690	170	270	110	630	310	3600	1200	900	1200(1—1/60d)	10
Longleaf Pine	6500	1300	1 610 000	720	180	300	120	520	260	3800	1300	980	1300(1—1/60d)	10
Shortleaf Pine	5600	1100	1 480 000	710	170	330	130	340	170	3400	1100	830	1100(1—1/60d)	10
White Pine	4400	900	1 130 000	400	100	180	70	290	150	3000	1000	750	1000(1—1/60d)	10
Spruce	4800	1000	1 310 000	600	150	170	70	370	180	3200	1100	830	1100(1—1/60d)	
Norway Pine	4200	800	1 190 000	590*	130	250	100	——	150	2600*	800	600	800(1—1/60d)	
Tamarack	4600	900	1 220 000	670	170	260	100	——	220	3200*	1000	750	1000(1—1/60d)	
Western Hemlock	5800	1100	1 480 000	630	160	270*	100	440	220	3500	1200	900	1200(1—1/60d)	
Redwood	5000	900	800 000	300	80	——	——	400	150	3300	900	680	900(1—1/60d)	
Bald Cypress	4800	900	1 150 000	500	120	——	——	340	170	3900	1100	830	1100(1—1/60d)	
Red Cedar	4200	800	800 000	——	——	——	——	470	230	2800	900	680	900(1—1/60d)	
White Oak	5700	1100	1 150 000	840	210	270	110	920	450	3500	1300	980	1300(1—1/60d)	12

These unit-stresses are for a green condition of timber and are to be used without increasing the live load stresses for impact.

NOTE.—The working unit-stresses given in this table are intended for railroad bridges and trestles. For highway bridges and trestles the unit-stresses may be increased 25 per cent. For buildings and similar structures, in which the timber is protected from the weather and practically free from impact, the unit-stresses may be increased 50 per cent. To compute the deflection of a beam under long-continued loading instead of that when the load is first applied, only 50 per cent of the corresponding modulus of elasticity given in the table is to be employed.

*Partially air dry.
l = Length in inches. d = Least side in inches.

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The truss span is designed to move vertically between cables on the upright corner posts of fabricated steel towers mounted on the abutments or piers on which it rests when closed. The guides on the corner columns provide a means by which lugs fastened at the corners of the lift span guide the structure as it is raised and lowered, at the same time preventing any horizontal swaying movement.

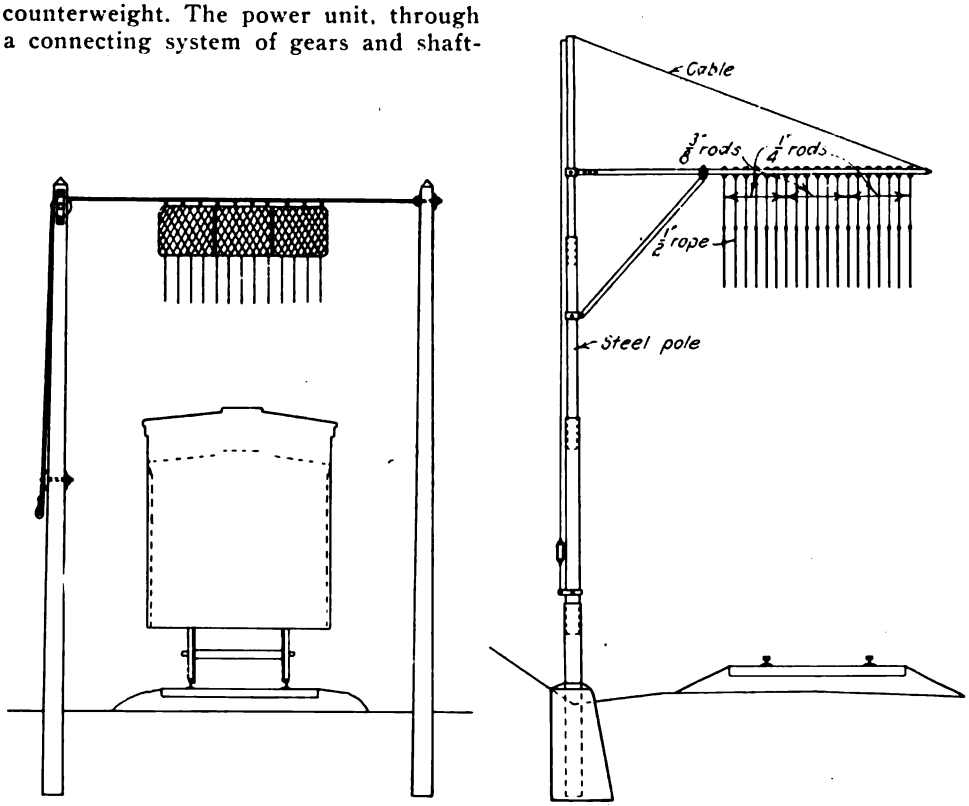
Of the various auxiliary devices used to facilitate the lifting, the balance maintained by counterweighted cables is perhaps the most common, a nest of cable being fastened at each of the four corners of the lift span and passed over sheaves at the top of the tower and down to the attached counterweight. The power unit, through a connecting system of gears and shafting, moves the span between the tower posts with the aid of wire ropes that are continuous from points at the tops of the towers over the sheaves and drums to points at the bottoms of the towers. On account of the counterweighting the hoisting equipment is only required to overcome friction, snow load, etc. Generally a system of locks is used to fasten the span down on the piers and to hold it automatically at any desired elevation, their operation being controlled from the bridge tenders tower in connection with the other operating machinery. The extreme elevation of a vertical lift bridge is designed to accommodate the highest vessels navigating the waterway and is seldom over 100 ft., although in a few cases it is as much as 135 ft. above high water.

Vertical Lift Bridge

Ordinarily only a few minutes is required to raise or lower a vertical lift span, the interval varying with the height of the lift, the weight of the span and the power of the operating machinery. While lift bridges generally include but one floor system, they are sometimes provided with double decks. This type of structure is sometimes built in cities, where the double deck is a matter of economy for two or more railway lines or for railway and street traffic. See Bridge. Also Bridge, Movable.

BRIDGE WARNING. A series of dangling ropes suspended over a track from a cross arm or cable, at a suitable height above the rails to strike the heads of trainmen standing on moving cars, and at a suitable distance in advance of a low bridge or other overhead obstruction, to warn them to stoop immediately to avoid being struck by the obstruction when the train passes under it. The ropes must swing freely in place to give certain warning to the man on the car but without hurting him.

Single track warning ropes are usually hung from a horizontal arm fastened at one end of a vertical pole planted about 8 ft. to one side of the center line of track. Where several tracks are to be guarded the ropes are suspended from a cable supported between two span poles. To prevent the force of the exhaust from locomotive stacks from tangling the ropes over the cross arm or cable, they are sometimes hung from the lower ends of heavy wires which depend from the cross arm, or cable, the wires being almost as long as the ropes, or a light frame enclosing a wire netting is



Two Types of Bridge Warnings for Single Track

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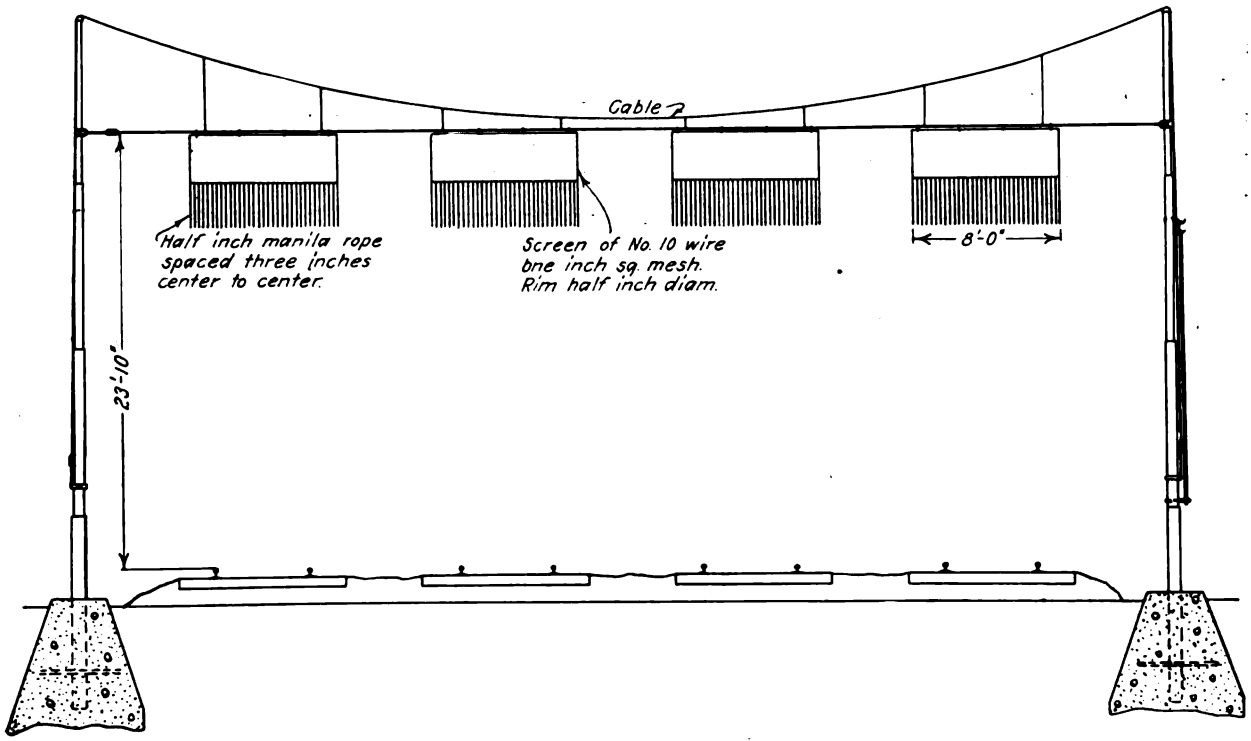

Multiple Track Bridge Warning

used instead. The cross arm with the ropes, etc., when attached to one pole is braced or trussed to bear its load, the pole being preferably set in concrete to hold it upright. These warnings are used to guard all overhead obstructions which encroach below the minimum standard clearance of 22 ft. above the top of the rails, and are placed approximately 100 ft. in advance thereof, while the ropes depend about 6 in. lower than the obstruction of which they are intended to give warning. The posts and arms are usually of wood or steel, the wood post being about 8 in. by 8 in., and ends are wound with cord to prevent raveling.

BRUSH, PAINT (Bridge). A round or flat, soft bristle brush used to apply paint to the surface of a structure. It consists of closely-spaced bristles, the broad shank being set in a short wooden handle. Brushes used for painting steel bridge chords, columns, girders, etc., are generally flat and about 4 in. wide while those used for the smaller members of

Flat Wall Paint Brush

Combination Paint and Varnish Brush

Flat Varnish Brush

Oval Paint or Varnish Brush

Wall Paint Brush

Flat Chiseled Varnish Brush

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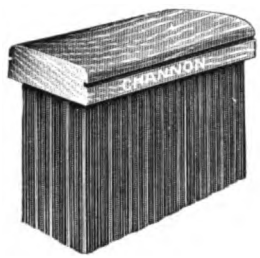
the structure such as rods, braces, lattice bars, etc., and for crevices and corners are commonly flat and about 2 in. wide or round and about 2 in. in diameter.

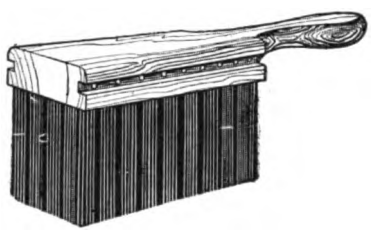
BRUSH, WIRE. An abrasive tool used to scrape paint, dirt, mill scales, etc., from metal surfaces, especially of bridge members.

A wire brush consists essentially of a series of nests of short, closely spaced, straight steel wires fastened at right angles into one face of a rectangular-sectioned wood block. The steel wires are from 1⅝ in. to 4 in. long and are commonly tempered to withstand hard usage. Ordinarily the block, which is of convenient size, is grasped in the hand like a scrub brush though some styles have handles projecting from one end like a blacking brush. This brush is commonly used by bridge painters to clean the surfaces of the metal before painting is begun.

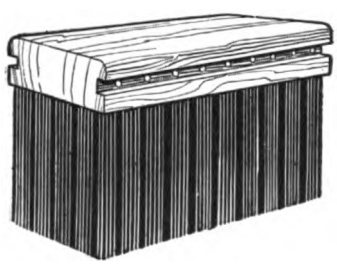


Flat Wire Casting or Foundry Brush

Scrub and Scratch Brush



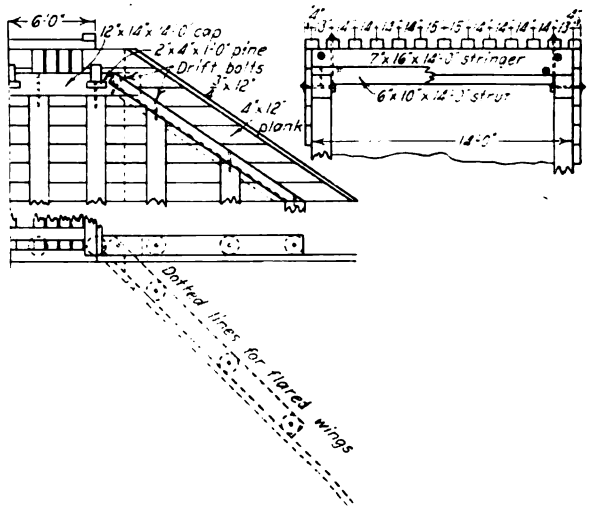
Steel Wire Casting or Foundry Brush with Handle



Steel Wire Casting or Foundry Brush with Solid Back

BUCKER-UP, RIVET. See Holder-on. (Pneumatic).

BULK HEAD. An upright retaining wall erected at a bridge end, usually of plank placed horizontally edgewise one on the other, behind and parallel with the end to retain the embankment.



Bulkhead of a Trestle Bridge

Bulk head planks are usually spiked to upright posts while vertical spacing strips, nailed at intervals between the wall and the bridge-end, prevent contact between the timber surfaces, thus introducing a sufficient air space, tending to minimize decay of the wood. See Trestle Bridge.

C

CAISSON. An artificial, water-tight enclosure used as a permanent foundation shell from which the material may be excavated and replaced with concrete or other masonry, the shell being employed only as a convenient means of placing the foundation in position.

Caissons usually are surmounted by cofferdams to

Heavy Caisson with Timber Sheathing and Steel Frame

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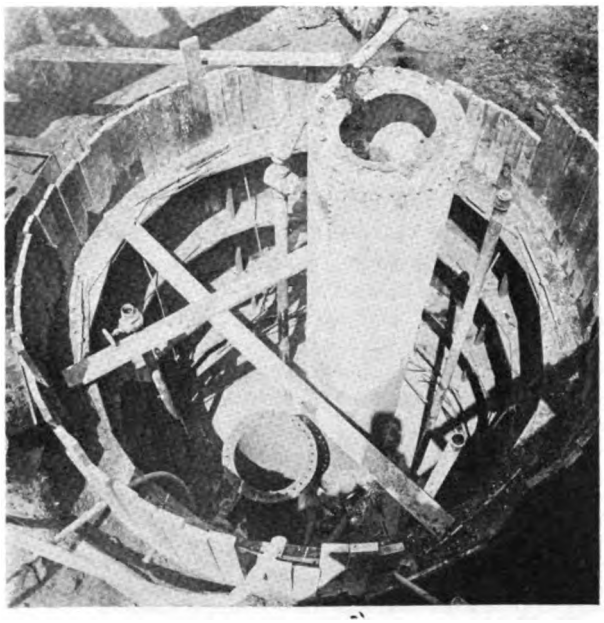
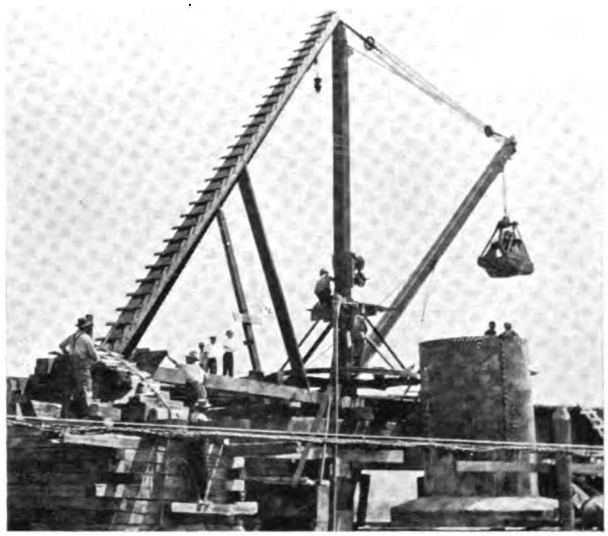
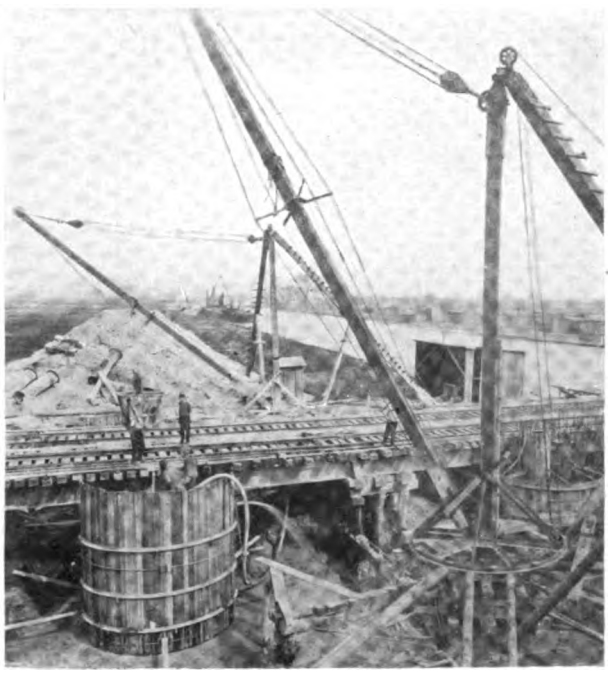


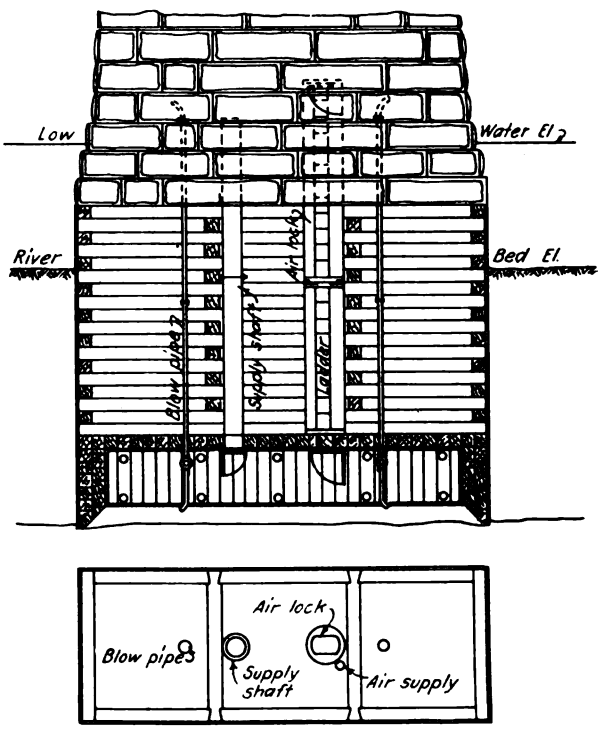
Interior of Caisson for Bridge Foundation



Excavating Inside of Steel Caisson



Caisson and Derricks for Bridge Foundations



Vertical Section Through Pneumatic Caisson and Pier

avoid extending the caissons above the low water level and to provide space to erect the permanent pier or other structure of the designed shape and finish. Caissons are commonly made of metal, concrete or wood or combinations of any of these materials. Though made in various forms, rectangular and circular sections and battered walls are favored, while the interior is frequently divided into compartments. The central portion of the caisson is sometimes filled with sand which is sealed within the masonry shell.

There are three principal types (1) box caissons, (2) open caissons and (3) pneumatic caissons. The box caisson has sides and a bottom but no top. It is commonly water-tight and used where no sinking is required serving merely as a container for the masonry of the foundation, being sometimes placed on piles. The open caisson has no top nor bottom but is sunk to a bearing by removing the earth from under it, the dredging usually being done through the water. A pneumatic caisson is bottomless, but is roofed, and compressed air is applied to displace

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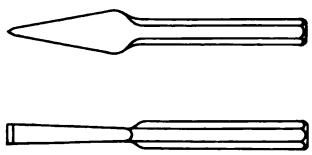
the water after which the material is dug out by hand.

CAP. A horizontal member secured to the tops of the piles or posts of a bridge bent, for the purpose of supporting the longitudinal members and their loads; that is, the stringers, girders or slabs and the floor system and track structure built thereon, as well as the live loads.

The dimensions of timbers used for caps of single track wooden trestle bridge bents are about 12 in. by 14 in. by 16 ft. if the timber is yellow pine, Douglas fir or wood of similar strength. Reinforced concrete caps are cast in place around concrete piles and have a width and depth sufficient to develop the necessary beam strength. The term cap is not applied to steel bridge members. See Bent (Wooden Trestle). Also Trestle.

CHISEL, CAPE. A cross-cut hand chisel used to cut grooves, key-ways, etc., in structural members. This tool is similar to a hand gouge except that the

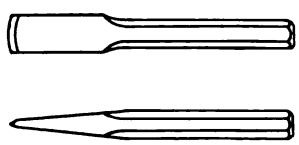


Cape Chisel

blade is somewhat thicker at the point. It is used in bridge erection in the absence of pneumatic tools. See Gouge (Hand).

COLD CUTTER. A steel chisel used for rivet busting and shipping and for cutting steel plates, etc.

A cold cutter consists essentially of a flat, wedge-shaped, cutting portion and a hammer head. The



Cold Chisel

Cold Cutter

hammer head, about 1½ in. square, has beveled edges while an eyelet located about midway of the head provides a means of attaching a wooden handle by which the tool is held in position. It is similar to a track chisel except that it does not have a blunt cutting edge.

COLUMN. An upright pillar designed to transmit to its foundations vertical loads applied to its top. The term is applied especially to the upright members of steel structures such as railway bridge towers or bents.

Steel bridge columns are usually built of structural shapes riveted together, while the ends are furnished with suitable bearing plates with connections for other members such as braces, etc.

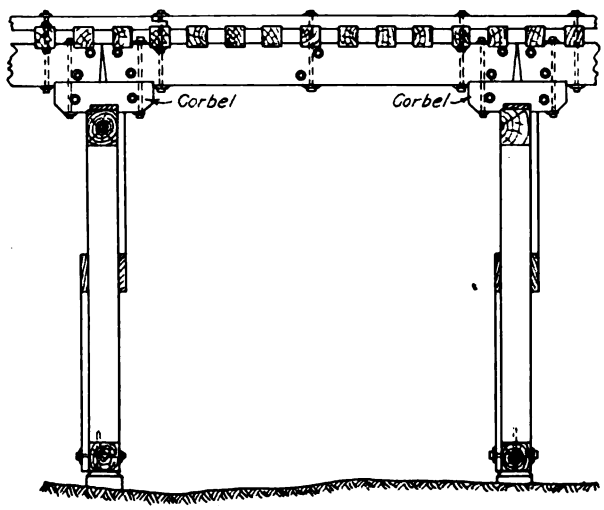
CONTINUOUS BEAM. A girder which extends over two or more spans and consequently has more than two supports, as the stringer chord of a timber trestle bridge. See Stringer Chord.

COPING. A top finishing course of masonry or special tile placed on the tops of walls, and designed to shed water to protect the interior from dampness and to prevent the surfaces of the wall from weatherstaining.

The top of a coping is usually beveled slightly from the horizontal or sloped from the center to shed water readily. It is used generally on wing walls, retaining walls, bridge abutments, piers, etc.

COPING COURSE. The top course of a masonry pier, usually projecting beyond the lower courses. See Pier. Also Coping.

CORBEL. A short section of a timber stringer, designed to be placed on a cap, parallel to the stringer which it directly supports for the purpose of improving the bearing of the joint between the



Frame Trestle Showing Corbels

stringers and to effect a reduction in the length of span, while affording a gain in bridge height at small expense for timber.

Corbels, which are not commonly used, are sections of stringers about 6 ft. long, bolted together in a chord which corresponds to the width of the main stringer chord. See Stringer Chord.

COVER PLATE. A flat steel plate used to reinforce the flange angles of a girder or the top of a bridge chord. See Bridge, Girder. Also Bridge.

COUNTERFORT RETAINING WALL. An inclined cross wall, usually triangular and built at the

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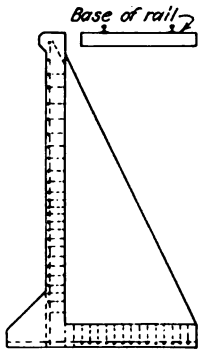
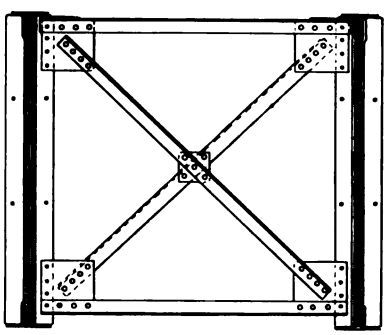
rear of a thin retaining wall to encase tie rods that connect the face wall to a rear projection of the footing. The function of a counterfort is the exact reverse of a buttress. See Abutment, Bridge.

COURSE (Masonry). A separate row, line or layer of stone blocks, etc., of a masonry structure. See Bridge.

CROSS FRAME. An end or intermediate cross brace fastened between the girders or trusses of a bridge to keep them in their correct relative positions and to resist the tendency to sway or tip under lateral pressure. See Bridge.



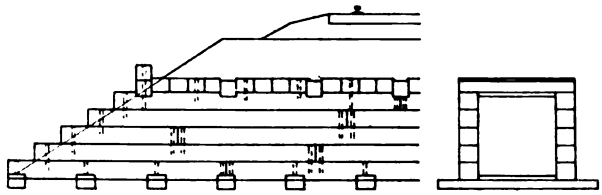
Counterfort Retaining Wall



Cross Frame

CULVERT. A covered structure of masonry, metal or timber, usually circular, and made segmental or rectangular in inside cross section to afford a passageway through an embankment. It is usually built to accommodate a waterway, although stock passes, farm crossings, etc., are often in the same structural form.

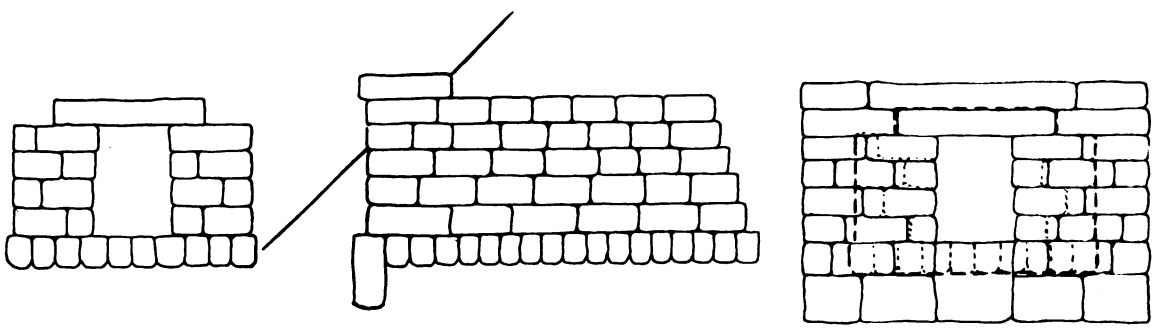
On account of the tendency to erode the earthwork and undermine the tracks, it is considered good practice to carry water through an embankment with the least possible diversion from its natural course, by means of small culverts at short intervals in preference to fewer waterways of greater area spaced farther apart, where conformation of the ground permits. On some railways which cross many wide and comparatively flat drainage areas, culverts are installed every half mile or closer, even where no natural water courses are apparent, with a view to disposing of water which might otherwise cause washouts by erosion along the upper side of the roadway, by overflowing between the ties, or by wave action in case of high winds.



Wooden Box Culvert

The inside sectional area of a culvert is determined by the maximum amount of water to be carried in a given time. Particular attention is paid to the extent and contour of the wings at the inlet and outlet to avoid any offsets or rough finish which might tend to deflect the current, increase friction and thus reduce the carrying capacity. The efficiency of a culvert is affected also by its elevation and gradient which are most favorable when they correspond closely to the natural fall of the ground, while the wings which are shaped to conform with the slopes of the embankment, if not skewed are preferably flared from the axis of the culvert to include the width of the stream from bank to bank, thereby providing means of ingress to the greatest amount of water the culvert will carry. Other conditions being equal, the culvert with the smoothest and most regular wet surfaces will carry the most water.

A culvert must be designed to withstand the weight of the superimposed loads and the lateral pressure of the earth on its side walls. The embankment load is distributed over the foundation by offsets on the wall footings, or by building an invert over all or portions of the floor space between the walls. Foundations are not as important in culverts as in bridge piers or abutments. Moderate settlement of a culvert is not a serious matter if proper allowance is made in establishing the grade of the floor, provided the barrel is divided into units that are designed to withstand settlement without distortion. By this method the use of pile foundations



Stone Box Culvert

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can be avoided except where the conditions are unusually unfavorable.

Generous provision for strength in the floor and the wall footings is considered good practice, insuring a degree of safety in the culvert in case of damaged foundations, as in washouts behind the walls or beneath the floor. To prevent such damage, the earth is tamped carefully and firmly behind the walls to a height above water if practicable, while in some cases a central bulkhead is built at right angles to the long axis of the structure to interrupt the flow of water more effectually along the outer surfaces of the walls which has a tendency to find its way through the embankment. Disastrous washouts sometimes occur on account of eddying currents at the inlet, usually on account of obstructing debris or high water. When the upstream half of a culvert is thus ruined it is frequently more expensive to replace than a complete washout, for the water usually must be flumed through the existing waterway while the tracks are supported on falsework and the inlet renewed. It is considered good practice to guard against such eddies and probable damage by building culverts of ample capacity and by extending end aprons and wing wall footings to the general depth of the side wall footings, or deeper if needed to obtain firm foundations. Even more important is the thorough cleaning away of debris from the vicinity of the inlet, as well as careful watching and clearing of floating brush, etc., in times of flood, for any eddy started by a partial obstruction may attain such force with rising water that it will undermine even a deep foundation. Water falls or eddies at the outlet, while not so serious owing to lack of pressure, are sometimes responsible for undermining wings, walls and culvert ends. The remedy is usually an apron and rip rap or paving from the end of the culvert for a sufficient distance down stream, or the construction of deep masonry bulkheads between the wing wall footings.

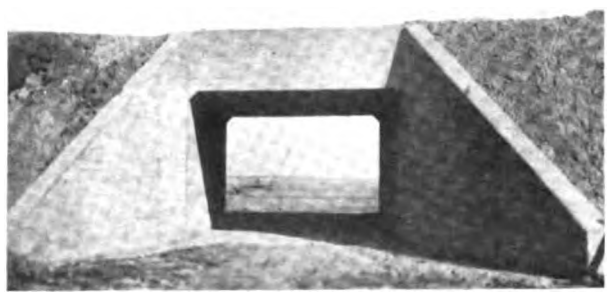
Maintenance involves the occasional lengthening or replacement of culverts as well as the construction of additional openings and the abandonment of others due to changing drainage conditions, etc. If possible the structure is made straight and the grade uniform from end to end. It is frequently necessary, however, to skew the culvert which is preferable to making a bend or angle in the barrel, which tends to hold obstructions. When a culvert must be replaced the new structure is preferably built alongside the old one which carries the water until the replacement is fully completed. After the water is turned through the new course, the abandoned culvert is filled carefully to prevent the embankment from caving. Additions to culverts are usually made under conditions which justify permanent construction. The bond between the old and new work is of importance, the new portion preferably being of the same material as the old structure.

Arch culverts are made of plain or reinforced concrete, and sometimes of stone masonry or pure iron shapes. These culverts are usually segmental and more commonly semicircular arches with masonry or paved inverts. While the wings are sometimes in line with or at right angles to the long axis they are commonly set at a 30 deg. angle or skewed at any angle to correspond with the slopes of the embankment. Box culverts are built of all sizes, up to 20 ft. span or more, the heights depending on the waterway conditions. Pipe culverts made of reinforced concrete, cast iron, pure iron, (usually galvanized), riveted sheet iron and earthenware tile are in common use on railways. They may be circular, oval, semicircular, triangular, etc., in section and may have plain butt, bell and spigot, mortise and tenon, or any of the various styles of lock joints. Some types of culvert pipes are made in two or three sections which may be nested for shipment and fastened together with flanges or locking devices.

Embankments are sometimes tunneled to replace culverts, in which case a line of pipe is the usual replacement. This work is best done in winter when the ground is frozen and the stage of water is low. The embankment slopes are first excavated as far as convenient toward the center line. A tunnel is then projected from each end, preferably by driving bevel-end planks forward horizontally behind rectangular braced frames of timbers, 3-in. by 8-in. by 8-ft. planks and 12-in. by 12-in. timber frames being commonly used.

Box Culverts

Box culverts are commonly made of reinforced or mass concrete or other masonry and sometimes of dry stone or wood. Reinforced concrete is favored for permanent culverts, largely because of its economy and adaptability to wide span slab construction, the wide distribution of its constituent materials and the readiness with which the structure may be poured in place. With the development of reinforced concrete, the box culvert is being used largely for structures where the stone or concrete arch was formerly the only type available. While the arch culvert can be built with little or no reinforcement, as compared with the box, the form work for the latter is simpler and cheaper. Stones laid in mortar are used sometimes to build culvert walls, the tops being made of stone or concrete slabs. Dry stone box culverts are sometimes built, especially where stone in suitable strata may be quarried close to the culvert site. Under pressure, water tends to force its way out of crevices between the blocks of dry stone walls and wash away the embankment. Although wood box culverts are temporary structures, their service life may be prolonged by preservative treatment of the timber, while by making the original box large enough, it may be renewed when



Single Concrete Box Culvert

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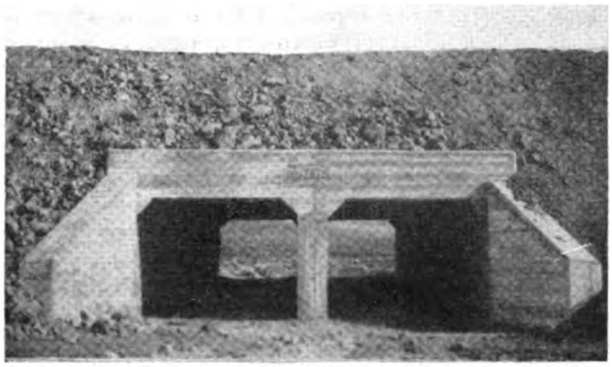

Double Concrete Box Culvert

necessary by relining with new timber; that is, by building a new box inside the old one.

Reinforced Concrete Pipe Culverts

Reinforced concrete pipe, which has come into common use for culverts, has the advantages of comparative economy and durability. Circular or oval sections are favored and in general use, although pipes of triangular section with rounded corners are sometimes employed. The pipe joints are of the mortise and tenon, plain bell, bell and spigot and lock types. The mortise joint possesses the advantages of simplicity and economy. It is readily made with a minimum of shaping of the reinforcement, it may be rolled in a straight line and laid on a plane surface. On the other hand, the plain bell and the bell and spigot joints are more adaptable to curves or yielding foundations. Triangular pipes laid flat afford a large floor area and may be tamped in place readily. The reinforcement applied to concrete pipes is commonly meshed wire or steel rods or both, the medium sizes usually having a cylindrical mesh supplemented by longitudinal rods suitably spaced about the periphery. The concrete is usually a fine aggregate, poured wet about the reinforcement and in place within the forms which stand on end. The finished pipe is preferably cured for several weeks or months before being transported. It is commonly used in diameters of 2 ft. to 5 ft. and lengths of 3 ft. to 8 ft., although pipes as wide as 7 ft. are sometimes used for under crossings for stock, etc. A common size is 3 ft. in diameter made in sections 8 ft. long.

Metal Pipe Culverts

Metal pipe culverts are generally classified as seamed or seamless; that is, a type formed by riveting or bolting thin plates of metal together as distinguished from another which is cast integrally in a cylindrical mold, both types being made preferably in lengths short enough to admit of ready handling, the material being variously treated to prevent pitting and corrosion. The treatment usually consists of a bath in molten zinc to galvanize the plates; or a bath in asphaltic or mineral paint, or a coal tar pitch varnish. A seamed pipe commonly consists of plates of iron or steel, usually corrugated to increase their strength, riveted together in lengths of 2 ft. or more to form a circular section 30 ft. or less in length. These metal plates, sometimes of pure iron, generally cut in rectangular shapes, are bent between rolls, two or more sheets being riveted together to form a section of pipe though sometimes the plate is a narrow strip bent to a spiral and continuously riveted together to form a length of pipe complete in section. In some cases the plate is bent to a semi-circle with terminal flanges through which it is riveted to flat bottom plates to form an arch culvert used preferably under shallow embankments. In any case flange, lap or riveted joints hold seamed pipes together to form the culvert, while sometimes the plates are bent to a semi-circle and flanged longitudinally so that they may be knocked down, nested to facilitate shipment and then assembled and bolted together in the field.

Seamless pipe is commonly of three kinds, cast iron, wrought iron and steel, cast iron generally being used for heavy duty pipe culverts under railway embankments while wrought iron and steel are more often used for water ways under pressure, as for locomotive water supply. Cast iron is a rust resisting metal, its noncorrosive properties, strength and permanence having brought it into general favor for pipe culverts. The ideal form of construction for a railway culvert is a single jointless tube. This type of pipe, however, is impracticable and for this reason cast iron culvert pipe is commonly made in lengths of 12 ft. While circular pipe culverts are generally used under all embankments, drainage under shallow fills and through ballast is sometimes carried in an iron tube which is semi-circular in section. This type of culvert is designed to be laid with rounded portion uppermost, the pipe being made in sections of 3 and 5 ft. to facilitate handling. The joints of cast iron culvert pipe are commonly of the bell and spigot type though they are also sometimes equipped with prepared joints consisting of cast iron wedge-shaped keys cast on the spigot and bell, allowing the spigot keys to slip past the bell keys. Sometimes cement mortar is used to join the section but more often the spigot end of the pipe is laid loose in the socket of the bell, affording enough flexibility to lay the pipe on a vertical or horizontal curve without breaking the joints. Although cast iron culvert pipe is made in diameters of 7 ft. and under, it is seldom used under high embankments in diameters less than 2 ft., while the large pipes are sometimes used for stock passes. It is considered good practice to lay a cast iron pipe culvert on a firm foundation, so that the sections will have an even bearing, while the fill about the culvert being carefully tamped under and around the sides. It is often advantageous to build a head-wall at the inlet and outlet of the culvert to retain the slopes, to shorten the culvert and to prevent water from undermining the ends. Where a railway embankment crosses a stream which is subject to sudden floods it is sometimes provided with two or more parallel lines of pipes while the head-walls are supplemented with wings. Advantages of cast iron pipe are long life, indestructibility, permanence and high scrap value.

Earthenware Pipe Culverts

Earthenware pipe culverts consist of lines of vitrified bell-end culvert pipes, made by mechanically molding prepared clay and sometimes other mate-

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rials in suitable sections and then submitting the pieces to a high temperature in ovens until they are gradually burned to a rock-like hardness. These pipes are commonly made in lengths varying from 1 to 3 ft. and in diameters up to 3 ft. with plain bell ends, by means of which the sections are joined readily to form continuous waterways, the joints being sometimes filled with cement grout. The shorter lengths of pipe are usually of small diameter while the larger pipe suitable for railway use is made in lengths of 2 ft. 2½ ft. and 3 ft. Earthenware pipe is generally classified as either drain tile or vitrified pipe. Of these two classes the vitrified pipe only is used for railway culverts on account of its superior strength, durability and density. It is burnt to a glassy, non-absorbent hardness which insures resistance to moderate pressure. While tough, it is also brittle and will crack or break under severe, unequal or sudden exterior pressure and is therefore more generally used for culverts under highway grade crossings, farm crossings, etc., than under railway embankments. When used under high railway embankments it should be large enough for a man to pass through and clean.

It is considered good practice to lay earthenware pipe culverts only on earth foundations which have enough resiliency to protect the sections and which contain no boulders or other unyielding portions which may tend to crack the bottoms of the pipes, while there should be a cushion of earth embankment over the top at least equal to the inside or the culvert.

CULVERT, ARCH. A culvert with an interior cross section in the form of a segment of a circle or some other curve, usually a semi-circle. Arch culverts are usually made of reinforced concrete, sometimes of stone or other masonry, of sections of pure iron bent to shape, etc. See Culvert.

CULVERT, BOX. A culvert of rectangular cross-section designed to carry a water course or passageway under and through a railway embankment or highway grade crossing approach. See Culvert.

CULVERT, PIPE. A culvert made up of a line or parallel lines of short earthenware, concrete or metal tubes, laid end to end to form a passageway usually to carry away superfluous water.

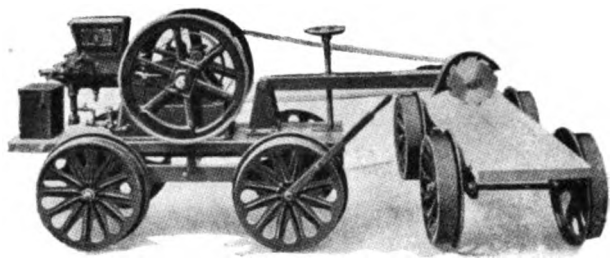
The culvert is commonly laid in a straight line, at right angles to the track on the natural gradient of the stream which it carries except for the slight camber necessary to allow for settlement induced by the weight of the earthwork on the foundation. To prevent damage from water scour the earth is tamped about the outsides of pipes after they are placed while the ends are preferably given the protection afforded by masonry end walls or wings. See Culvert.

CUT WATER. The salient, angular, up-stream nose of a bridge pier, usually so shaped as to deflect water carrying drift and ice with a view to preventing damage to the structure.

As piers located in streams are exposed to the action of ice and drift, they are commonly provided with extended pyramidal cut waters shod with metal, especially on the front inclined edge, which acts as a fender to deflect ice and drift and by so doing prevents the formation of eddying currents which, when diverted downward, tend to displace the earth around and under the pier and resulting sometimes in undermining the structure. This form of cutwater is most commonly used in latitudes where the stream is likely to become choked with floating ice, while in streams with little or no ice to contend with, a rounded cutwater is preferable since it splits the current farther up stream and deflects floating material before it strikes the end of the pier. Usually the upstream edge of the cutwater is battered about 4 in. in 12 in. to impart a sliding or rolling motion to the drift. Sometimes loose stone is piled around the base of the cutwater to ward off ice and drift as well as to prevent scour due to eddying currents, while protecting clusters of piling are driven upstream in front of the pier as further means of protection.

D

DAPPER, TIMBER. A power-driven cutting head and circular saw designed to cut channels or gains across the faces of timbers suitable for seating



Toohey Timber Dapper
The National Concrete Machinery Co.
(See Page 754)

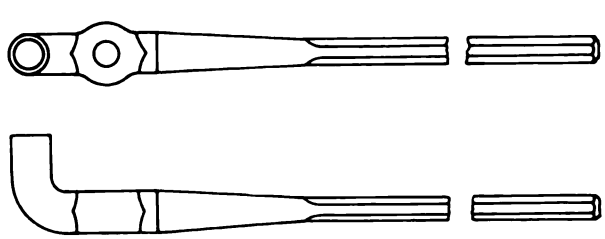
tie plates on cross ties, forming daps in bond timbers of wooden bridges, sizing caps and stringers, etc.

An advantage of the machine is the exactness and rapidity with which many timbers may be sized to one thickness as compared with the process of hand marking, sawing and adzing.

DEAD LOAD. The estimated weight of the entire suspended structure as distinguished from the live load.

The dead load of a bridge is the weight of the structure itself, whereas the live load consists of the weights of engines, cars, etc., which it is designed to support. See Live Load. Also Bridge.

DOLLEY, RIVETING. A hand riveting tool, sometimes called a bucker-up, usually a short steel bar with an offset or crooked shank (which may be



Heel Dolley

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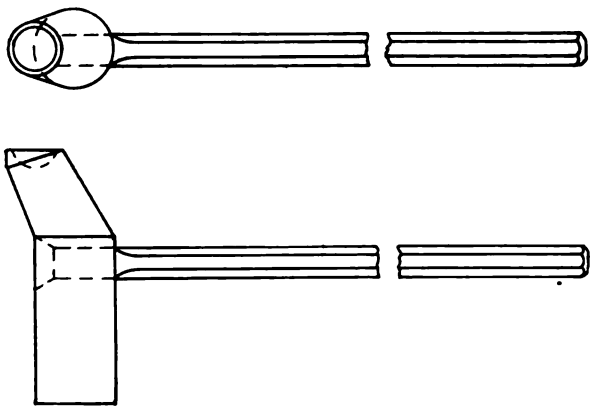
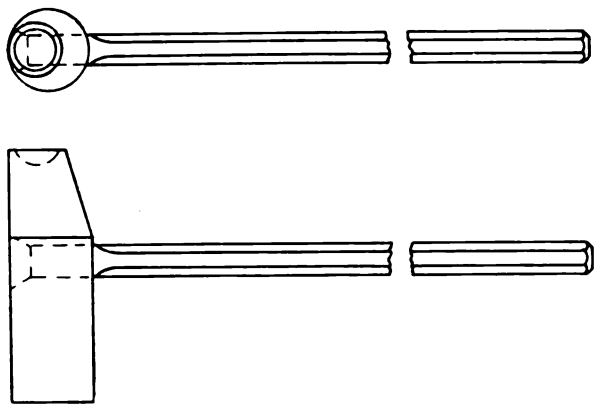
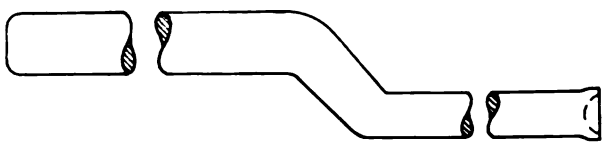


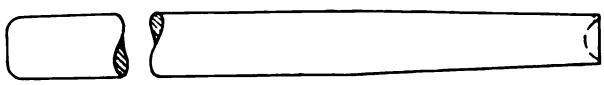
Offset Spring Dolley



Spring Dolley



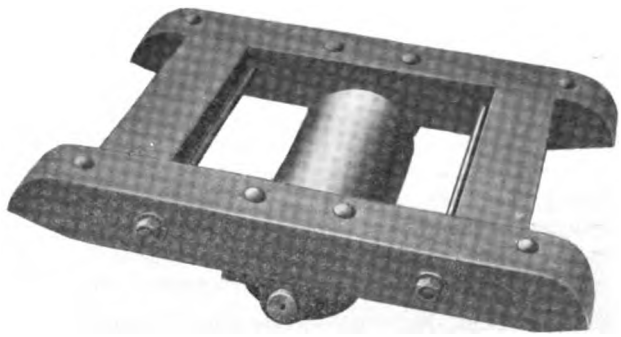
Goose Neck Dolley



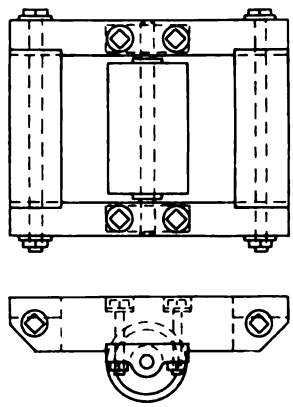
Straight Swing Dolley

variously shaped to reach otherwise inaccessible rivets) terminating always in a cup-shaped end to be pressed against the rivet to hold it in place while the head is being formed on the other end of the rivet by the riveting hammer and snap. The dolley is used against the manufactured head of the rivet while the snap is used to shape the heated stock end to its finished form. See Field Rivet. Also Riveting.

DOLLEY (TIMBER). A device consisting of a single wide roller mounted in a frame serving as a platform and used as a truck for moving long heavy



Contractor's Dolley

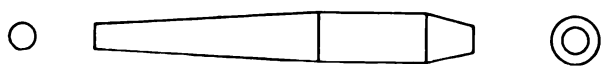


Common Form of Timber Dolley

beams as bridge stringers, columns, etc., or when inverted, as a stationary roller.

DRIFT PIN. A round metal pin designed to be driven with a hand hammer to line up or match the holes through the various pieces to be held by the rivets.

A drift pin is a straight steel pin 5 in. to 8 in. in length, of the same diameter as the rivet hole in which it is to be driven, and with one end tapering abruptly while the opposite end is tapered more gradually.



Drift Pin

DRY MASONRY. A term applied to construction with blocks of stone, etc., without mortar, the blocks being laid in courses with broken joints and without any bond, as in hand packed dry retaining walls.

Dry masonry is commonly used as a means of protecting the slopes of an embankment from water scouring or to hold a slope which has a tendency to slide and spread at the toe. It is also used around bridges and culverts to retain and protect the toe of the slope at the head of the embankment and to prevent the channel from becoming blocked. Dry masonry is not a permanent construction and is not considered in the same class with masonry set in mortar. See Masonry, Ashlar.

E

ERECTION, BRIDGE. The building of a bridge in place, with the materials and by means of erecting diagrams, plans, specifications, plant, etc., furnished for the purpose. See Falsework. Also Erection Diagram.

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ERECTION DIAGRAM. An outline diagram of a bridge or other fabricated structure identifying each fabricated member by its mark or number.

Erection diagrams usually show the relative locations of all parts of a structure, shipping marks for the various members, their main dimensions, the number of pieces in a member, the packing, of size and grip of pins and any special features or information, such as approximate weights of parts, that may assist the erector in the field, especially in designing falsework and selecting erecting equipment.

EXPANSION. The lengthening of the metal in the members of a structure such as a fabricated steel bridge.

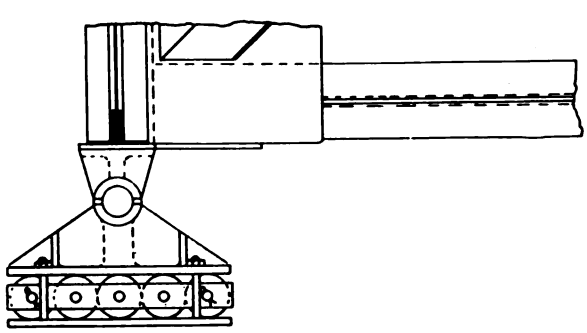
Expansion of girders, trusses, etc., is usually taken up by means of sliding plates or rollers resting on the abutments or piers beneath the super-structure, by oblong bolt holes in the bed plates of the spans or by some similar device which will permit variations in length due to changes in temperature. The mean value for expansion of steel per deg. F. is 0.0000065, allowance therefore by means of slide plates or rollers being provided accordingly in all spans.

EXPANSION JOINT (Structural). A joint or space which permits parts or sections of a structure to expand and contract with changes of temperature.

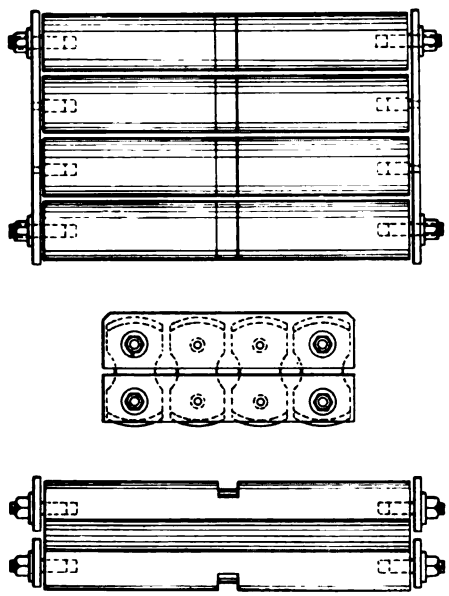
The placing of expansion joints in either masonry or steel structures of considerable length is essential to good construction, since longitudinal movements caused by changes in temperature tend to buckle or crack structures which are not so protected. In masonry arch bridges having wide spans and spandrel walls it is common practise to introduce an expansion joint on either side of the crown of the arch, extending from the extrados of the arch ring to the top of the parapet. Long concrete retaining walls are commonly constructed with expansion joints 25 ft. to 75 ft. apart, while in masonry bridges it is the general practice to provide joints about 1 in. wide filled with heavy tar paper, pitch or other like materials. In structures where the expansion joints are exposed to traffic it is good practice to protect exposed concrete edges by means of soft steel plates set on edge and anchored into the body of the masonry.

EXPANSION ROLLER. One of a number of parallel cylindrical or segmental steel rollers contained in a casting designed to permit horizontal movement due to expansion and contraction of steel bridge spans.

An expansion roller device is generally placed at one end of a bridge span and usually consists of four or more rollers, the diameters of which are not less than 3 in., while their length seldom exceeds 4 ft., the number and dimensions depending primarily on the length of the span and the load to be carried. They are generally arranged to travel between steel plates or castings, one bolted to the masonry below and one fastened to the end of the span, the rollers being coupled together by means of side bars which hold them in position. The extreme play of the rollers is usually only a few inches, depending on the length of the span and the range in temperature.



A Common Form of Expansion Roller



A Common Type of Segmental Bridge Rollers

EXPANSION SLOT. An oval slot in a metal base plate, designed to afford space for the plate to slide slightly with the expansion and contraction of the steel in the member, although secured to the base by means of the holding down bolts.

EXTRADOS. The outside convex surface of an arch. In small concrete culverts, this surface is frequently not all built under forms, but they are extended only high enough above the springing lines to keep the fresh concrete from flowing or bulging. the exposed crown portion being troweled or shovel finished. See Arch.

EYE-BAR. A flat steel connecting rod with rounded ends containing pin holes, used principally as tension member of a pin connected truss.

An eye-bar is of uniform rectangular cross-section between the end connections. For ordinary structures this type of bar has a minimum thickness of $\frac{5}{8}$ in. for bars 2 in. to 10 in. in width, though for heavier structures these dimensions are increased, while the head varies from $4\frac{1}{2}$ to about 24 in. in diameter. When the minimum stresses are light or where compression is possible as in the first two lower chord panels, for hip verticals or for diagonals

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subject to counter stress, eye-bars should not be used. Multiple eye-bar members are common, especially in bridge chords, main chains for suspension bridges, etc., where several eye bars are threaded on one connecting pin, alternate bars extend in opposite directions. See Truss, Pin Connected. Also Bridge.

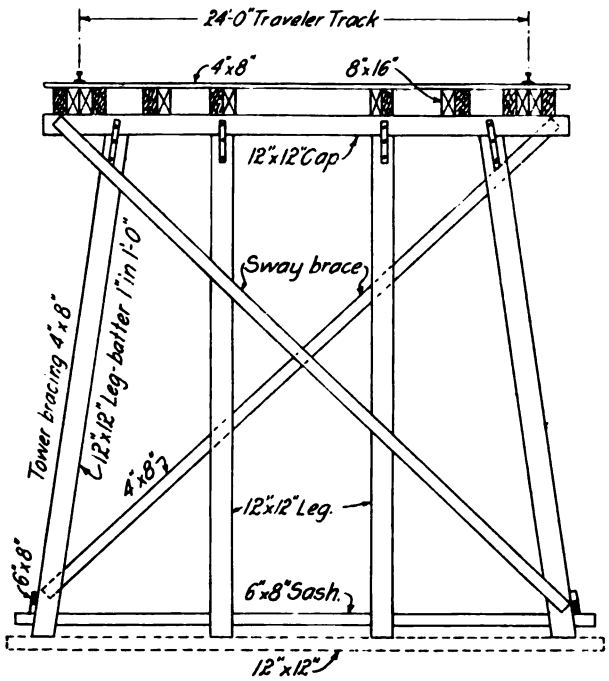
EYE-BAR HOOK. A steel grappling hook designed to be used in connection with a power unit and derrick to lift eye-bars.

This hook is made of two recurved flat steel bars bolted together scissors fashion, and bent to form opposite hooked jaws. The portions above the jaws form the arms and terminate in eyelet fasteners. See Eye-Bar.

F

FALSEWORK. A temporary structure by means of which an existing bridge may be replaced and dismantled while maintaining traffic, or a new bridge erected.

In some cases traffic may be diverted during replacement of bridges, but the usual maintenance replacement must be completed while the traffic goes on over the structure without interruption. Such



Typical Falsework Construction

requirements usually involve close calculation and study of train schedules in connection with the construction of a temporary structure, commonly a timber trestle bridge which will at once carry the traffic and not interfere with the placing of the new bridge members, while it permits of the dismantling of the structure to be replaced. Members of once-used steel bridges, as light deck trusses, are sometimes used for falsework, which is frequently a ruling factor in replacement projects as it must support the weight of portions of the old and new structures as well as the trains, and still be of such temporary assembly that it can be altered piece meal during the progress of the work. See Erection Diagram. Also Erection, Bridge.

FIELD BOLT. A threaded steel bolt commonly used in bridge erection to connect and hold the members of a steel structure until rivets can be substituted. See Bolt, Fitting up.

FIELD PAINTING. The application of paint to a metal structure immediately after erection as a means of preventing corrosion.

To obtain the best results, two or three coats of paint are preferable. The first is known as the priming or shop coat while the second is called the field or finish coat. During erection and after the members have been assembled, the field rivets are patch painted as soon as they are inspected and accepted and while the structure is being erected, after which the finishing coat or sometimes two coats are applied, ample time being allowed to permit each coat to dry before the next is applied. When two finishing coats are put on, it is well to have them of different colors so that no spots or portions of the surface will be missed when the last coat is applied. The painting of any metal structure should be carried on during warm, dry weather, preferably on clear calm days, as frost, dampness and dust are unfavorable to the adherence, drying, and appearance of new paint.

FIELD RIVET. A rivet used to connect the members of a steel structure during field erection.

A field rivet consists of a short stock and a button head, the stock being of such diameter and length that it will completely fill the rivet hole without forcing the metal between the members of the structure as well as form a perfect rivet head. If the rivet is too short either the hole will not be filled or the rivet head will be imperfect, while if too long the driving will force the metal out under the edge of the rivet-set, making a flange about the head. Before driving field rivets, the parts to be riveted are drawn together by means of field bolts and the holes fully matched by the use of drift pins, care being taken not to injure the metal with the pins. When the rivet holes are parallel and in line, the rivets, uniformly heated, are placed in position and driven preferably by means of a pneumatic riveting hammer. Generally about 15 per cent over the normal number required for each size of field rivet are furnished to take care of losses, imperfect stock and rejected riveting. See Riveting. Also Rivet.

FILLER PLATE. A steel plate commonly used as a shim between an end stiffener and the web of a plate girder or elsewhere in steel fabrication to avoid crimping the steel member to fit parts of unequal thickness.

FILLER RING. A steel plate used as a bushing or washer to prevent lateral movement between the eye-bars on a pin of a pin connected truss. See Bridge.

FLANGE PLATE. A steel plate which is riveted to the flange angles of a built-up girder.

The top and bottom flange plates are wider than the total width of the flange angles in place. Their primary function is to increase the amount of metal

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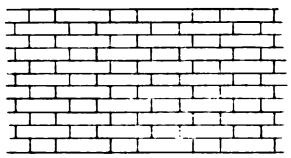
in the flange of the girder to resist flexure. See Bridge. Also Girder, Plate.

FLANGE RIVET. A rivet used to connect the flange plates of a fabricated steel girder to the web or the cover plates to the flange angles. See Rivet.

FLEMISH BOND. The disposition of brick in a structure, consisting of headers and stretchers placed alternately in each course so that the outer end of each header bears on the middle of a stretcher in the course below. See Masonry.



Sketch Showing Flemish Bond

FLOOR BEAM. A transverse beam connecting the main girders or trusses of a bridge and serving as a support for the minor members of the floor system, such as the stringers, eye beams, etc. See Bridge Floor.

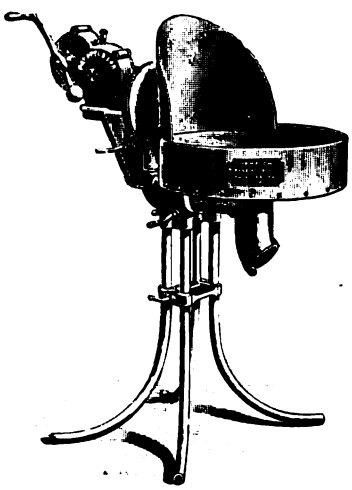
FLOOR SLAB. One of a series of floor sections, usually of reinforced concrete, commonly laid on the floor beams of a bridge deck to cover the space, to retain the ballast and to help to support the track structure.

FOOTING. The bottom course of a masonry structure, employed to increase the area of the foundation such as a bridge abutment or pier or a retaining wall.

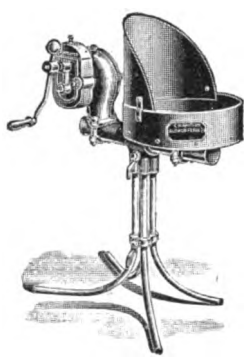
Masonry footings are commonly designed to project beyond the faces of the body to add to its stability as well as to distribute the weight of the structure over a larger area, thus decreasing the tendency to settlement.

FOOTING COURSE. One of the several courses at or near the bottom of a masonry pier, which are wider than the body courses. See Bridge Pier.

FORGE, RIVETING. A small portable furnace designed to heat metal so that it may be hammered into form, specifically a furnace for heating rivets.



Steel Rivet Forge

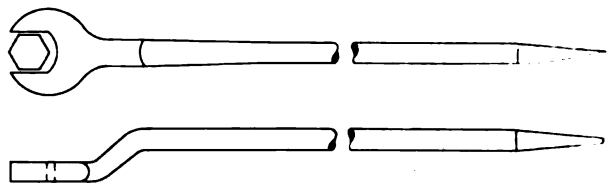


Geared Rivet Forge

This device consists essentially of a cylindrical iron hopper supported on a skeleton frame, with a geared bellows or blower attached at the rear. This type of furnace is commonly used to heat rivet stocks in the field during steel bridge erection. The hopper is filled with forge coal, lighted, and then blown by a blast from the bellows. See Riveting.

FORK WRENCH. A wrench used to tighten the nuts of temporary bridge bolts.

This tool consists essentially of a bar of metal having jaws at one end which are sometimes offset, and which are adapted to catch upon the head of a bolt or nut. A fork wrench is similar to a track



A Common Form of Fork Wrench

wrench except that it is shorter and lighter while the handle tapers so that it may be placed in a rivet hole to pull the members of a structure together.

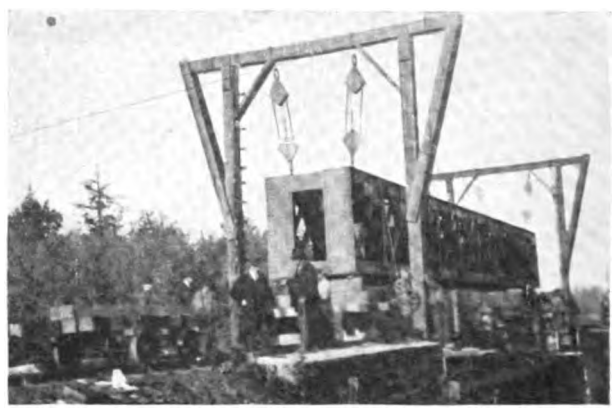
FRAME TRESTLE. A structure in which the upright members or supports are framed timbers (A. R. E. A.)

While the bents of steel and reinforced concrete trestles may be composed of members similarly disposed, they are not known commonly as framed structures. See Trestle Bridge.

G

GALLOWS FRAME. A temporary, portable, transverse bent (usually of wood), used as a support for tackle blocks especially to place girders.

This device consists essentially of two upright legs, one fastened to each end of a horizontal top cross timber long enough to span a car. Gallows



Gallows Frame Supporting Steel Span

frames are commonly used in pairs, one at each end of a girder to be lowered into place by means of steel blocks and cables rigged to the cross piece. The gallows frames are of such dimensions that the cars with the girders on will clear the frames and when in place beneath them the loads may be lowered into

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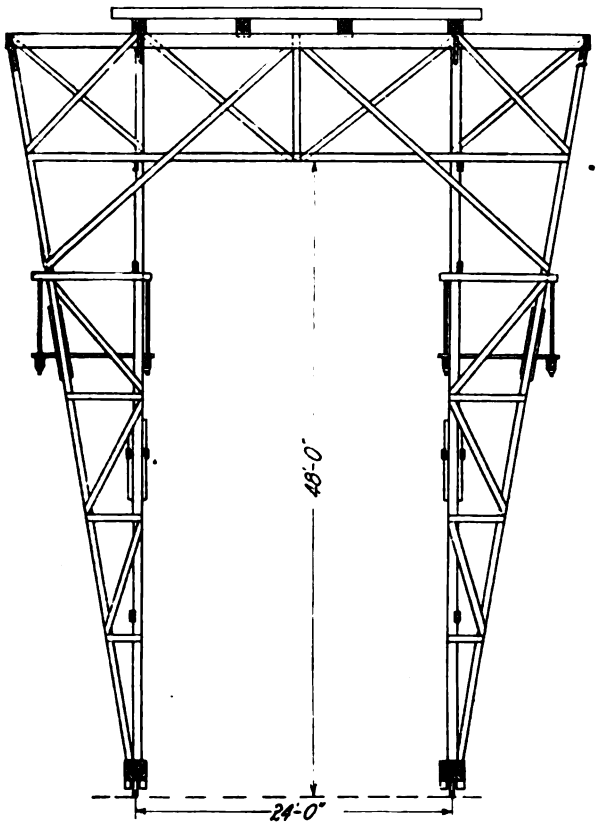
place or to one side for subsequent placing. See Gantry Traveler. Also Heavy Traveler.

GANTRY TRAVELER. A temporary structure, usually of wood, consisting of two or more transverse bents or gallows frames braced longitudinally



Gantry Traveler

and so constructed that it straddles the steel work to be erected. The gantry traveler is designed to be carried on a track supported on the falsework outside of the trusses while block and tackle rigged from the stringers are employed to handle the steel members. See Gallows Frame. Also Heavy Traveler.

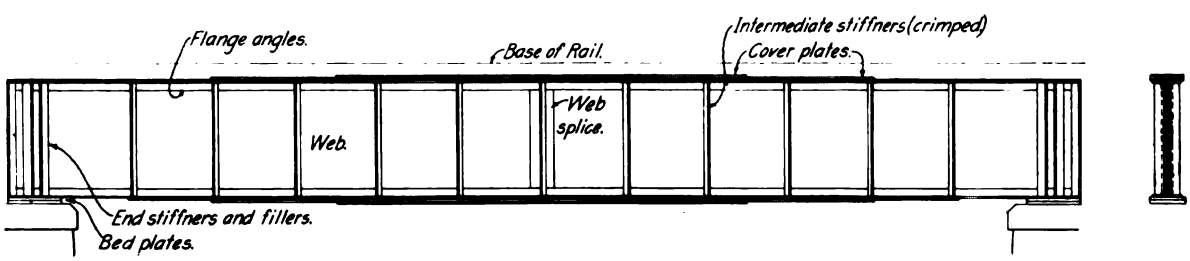
GIRDER, PLATE. A fabricated steel beam designed as a horizontal bridge member to be supported at the end bearings on upright bents or other substructures. Plate girders are commonly used in pairs and in parallel lines, under the track which they support; or the track may be supported on a floor system which is built between and riveted to the webs of the main girders.

A plate girder consists of a web or plate (preferably as deep as one-twelfth the girder span), to the top and bottom edges of which are riveted flanges made of pairs of steel angles. A flange designed for loading in excess of the capacity of the flange angles is reinforced with one or more cover plates, which extend entirely across both angles, and are riveted to them. The first cover plate of a top flange extends from end to end of the girder to protect the metal of the web and the backs of the angles from moisture. Other shorter cover plates may be riveted on top of this as the load demands. The cover plates of bottom flanges need not extend to the ends of the

Through Girder Supported on Cylinder Piers

girder. The web is stiffened against buckling with vertical stiffener angles in pairs which are also placed over the bearings and at points of concentrated loading. End stiffeners are on fillers, but intermediates are usually crimped over the flange angles. They are placed not farther apart than the depth of the unprotected web and never farther than 6 ft. Plate girders over 50 ft. in length are usually

Through Girder Bridge Encased in Concrete



Sketch of Plate Girder Showing Parts

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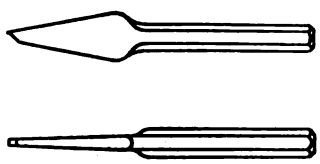
cambered, the rate of camber being about 1-16 in. in 10 ft.

The top corners of the through girders at the end of a bridge are usually rounded by bending the top flange down 90 deg. or less to improve the appearance as well as to prevent objects catching on the sharp edge. An advantage of a square end girder is that it may be used as either a deck or through girder whereas the round end type is not interchangeable.

Plate girders placed side by side in pairs and held by top and bottom cover plates, called boxed girders, are used where the vertical clearance beneath the the structure is restricted, and where through girders are undesirable. Girders may be similarly doubled and even trebled to obtain the desired strength for required loadings. Plate girder spans are frequently inserted in wooden trestles where wide spans are required, as over streets, railway lines and streams. They are also used in viaducts, grade separations and bridge structures generally where spans are within the economically suitable limits of 30 ft. to 110 ft. An advantage of girder construction is the readiness with which the units may be assembled and erected. See Bridge.

GIRT. A stiffening member usually running horizontally, or nearly so, from bent to bent of a bridge.



Hand Gouge

GOUGE, HAND. A one-piece hand chisel used to cut oblong holes, keyways, slots, etc. in steel.

This device consists of a flat V-shaped blade and an octagonal-sectioned hand hold. The V-shaped blade tapers in thickness from ¼ in. at its point to ⅜ in. at the shoulder and has a chisel-like cutting end which diverges to a rounded shoulder somewhat wider than the octagonal handle in which it terminates. It is from 9 in. to 11 in. in length and is generally used in bridge erection where pneumatic tools are not available.

GOUGE, HANDLE. A hand hammer with a chisel been used to cut key-ways, slots, etc., in steel.

This tool consists of a tapering circular nose about ⅝ in. in diameter at its narrowest point and 1½ in. at its widest which terminates in a square shank and an octagonal hammer face. The end of the nose is equipped with a chisel-like cutting edge while the shank is provided with an eyelet in which a wooden handle is placed to hold the tool in position. This tool, like the hand gouge and cape chisel, is seldom used except in the absence of pneumatic tools.

GUSSET PLATE. A plate of suitable dimensions to connect the converging members of a truss to a chord, etc., all the members being united to one plate or a right angled bracelet designed to stiffen the connection between an upright bridge member and a horizontal member.

H

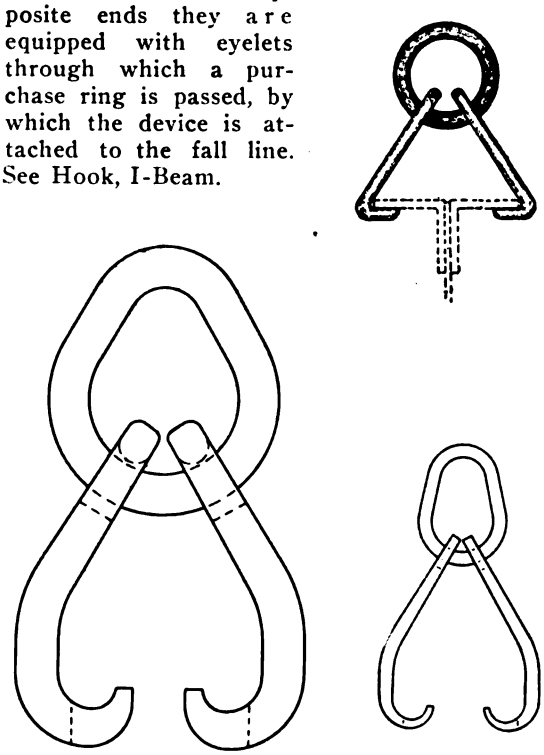
HAMMER, PNEUMATIC. A beating or striking tool driven by compressed air, and usually combining a cylinder, a reciprocating plunger or piston, a valve for automatically controlling the movements of the plunger, and a throttle valve for regulating the flow of compressed air to the hammer from the supply pipe.

HEAVY TRAVELER. A temporary wood or metal support for a derrick or crane designed to travel the top chord of a bridge to place the members of the structure in position as distinguished from a gantry traveler which straddles the trusses or girders and from a bridge erecting and locomotive derricks which move on the running rails of the track. See Gantry Traveler. Also Gallows Frame.

HOLDER-ON. (Pneumatic) A compressed air tool designed to hold a rivet firmly to place by pressure from behind while the riveting hammer shapes the head on the other end. See Hammer, Pneumatic.

HOOK, GIRDER. A short grab hook used with a derrick or crane to move girders.

This device consists of two rectangular or round steel bars, with the lower ends curved to form hooks while on the opposite ends they are equipped with eyelets through which a purchase ring is passed, by which the device is attached to the fall line. See Hook, I-Beam.



Three Types of Girder Hooks

HOOK, I-BEAM. A bridge erection grab hook designed to be used in connection with a derrick or crane for lifting structural members such as I-beams.

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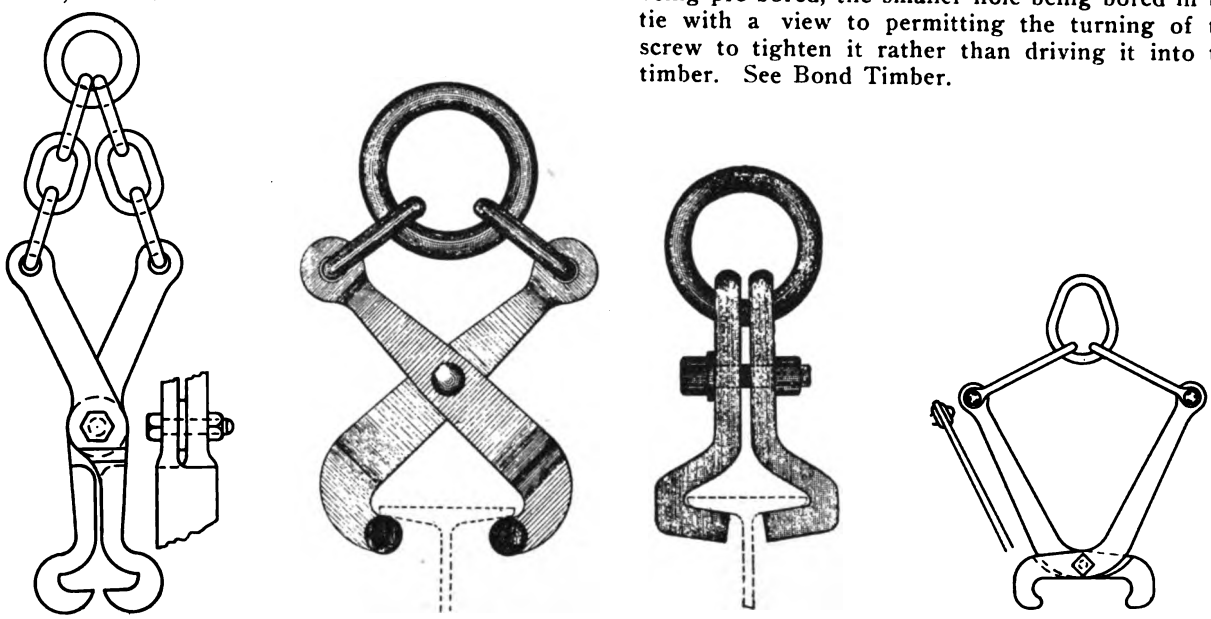
This device consists essentially of two metal bars of rectangular section bolted together scissors fashion, the lower extremities being bent to form hooked jaws. Eyelets at the ends of the shanks provide means of attaching shackles which are linked to a central ring by which the tool is operated. See Hook, Girder.



Four Types of I-Beam Hooks

I

INTERMEDIATE SILL. A horizontal member of a wooden bridge bent placed between the cap and the sill as a framing timber for the posts. See Trestle Bridge. Also Sill, Bridge.

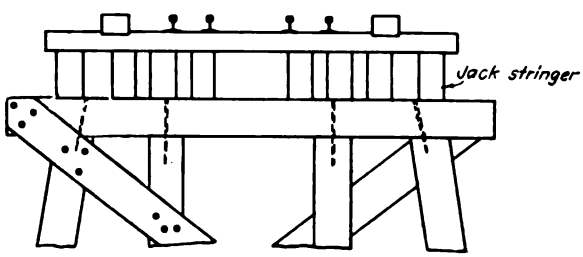
INTRADOS. The inner concave surface of an arch.

The symmetry of the intrados of a stone masonry arch depends on the nicety with which the arch stones are shaped. See Arch. Also Culvert, Arch.

J

JACK, BRIDGE. See Jack (Track Section).

JACK STRINGER. A stringer, sometimes called a safety stringer placed outside of the line of the main chord, as a support for the ends of the ties of a wooden bridge deck in case of derailment.



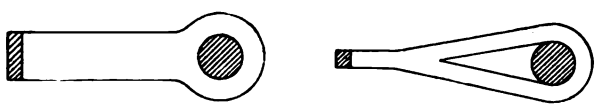
Sketch of a Frame Bent, Showing Jack Stringers

L

LAG SCREW. A tapering screw with a bolt head, also called a carriage bolt, sometimes used to fasten bond timbers to wooden bridge ties, the holes being pre-bored, the smaller hole being bored in the tie with a view to permitting the turning of the screw to tighten it rather than driving it into the timber. See Bond Timber.

LIVE LOAD. The moving load which a bridge is designed to carry, as distinguished from the load of the structure itself. See Dead Load.

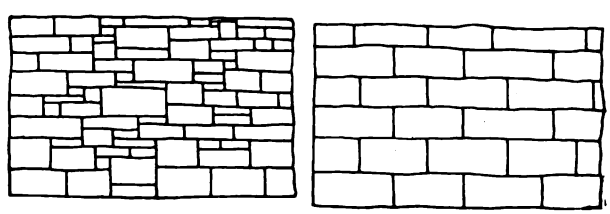
LOOP BAR. A metal rod used for lateral bridge bracing, specifically one of two steel rods or bars joined together by means of an intermediate adjustable turntable or sleeve-nut, while the opposite ends terminate in forged steel loops, which are used to fasten the brace to other members.



Loop Eye Bar

M

MASONRY. Any construction of stone or kindred substitute materials, in which the separate pieces are either placed together, with or without cementing material to join them; or encased in a matrix of firmly cementing material. (A. R. E. A.)



Sketches of Rubble and Range Masonry

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MASONRY, ASHLAR. Masonry built of squared or cut blocks of stone of rectangular dimensions.

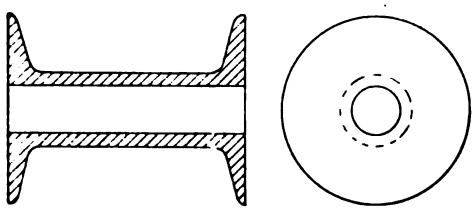
The term is generally applied to the best quality of stone masonry such as is commonly used in important railway structures. Ashlar stone is carefully tooled, well proportioned and laid in courses not less than 14 in, nor more than 30 in., the heights of the course commonly diminishing regularly from the bottom to the top of the structure. The side and bed joints are plane surfaces cut at right angles to each other, the exposed surface of the stone being either smooth or rock-faced with the edges pitched to true lines and batter. This class of masonry is being superseded by reinforced concrete on account of the relative economy in skilled labor and materials, the wider distribution of stone, gravel and sand suitable for concrete construction, the superior strength obtainable in monolithic construction, etc. See Masonry.

N

NEATWORK (Masonry). All that portion of a structure which is above the footings. See Bridge Pier.

P

PACKING BLOCK. A small block or spool of metal or wood, inserted between two members of a structure which are bolted together, as the stringers of a chord, to prevent them from coming in contact with each other. See Trestle Bridge. Also Stringer Chord.



Packing Block or Spool

PANEL (Bridge). The space between two adjacent floor beams of a steel truss, or between the vertical members of a truss.

The lengths of panels are varied to obtain the most economical inclination of diagonals compatible with an economical web system, weight of floor, etc. Increasing the panel length increases the weight of the floor system and decreases the weight of the trusses. The average length of panel of a Pratt truss or bridge of a similar type is about 25 ft. The spaces between adjacent stiffeners of a plate girder are sometimes called panels. See Bridge.

PEDESTAL (Bridge). A steel casting with a broad base designed to be set on a pier or an abutment as a support for one end of a truss or girder of a bridge; or on a footing to support one leg of a tower span or bent of a viaduct.

PILE. A member driven or jetted into the ground vertically or nearly so, to increase the power to sustain the weight of a structure or to resist a lateral force.

The pile derives its support from the underlying strata and from the friction of the ground against its surfaces. The purposes for which piles are used include the support of weights such as bridge piers and abutments built over them; the compacting of the ground between them; the formation of a wall to exclude soft material or water; and the resistance to the lateral pressure of adjacent ground.

Concrete Piles

The cross section of a bearing pile may be round, square, hexagonal, annular, etc., while in longitudinal section it may be tapering or uniform. The tip may be pointed or blunt, screw shaped or furnished with a disc. Piles placed edge to edge to form a wall for the resistance of lateral pressure are called sheet piles. While they vary in cross section they are usually symmetrical lengthwise and have interlocking edge devices, or they are rectangular in section and are driven in two or more staggered rows to form a tight wall with vertical lap joints. Sheet piling may be pointed or blunt according to the material of which it is made, the nature of the soil to be penetrated and the method of placing. Foundation piles act largely as columns when driven through soft or fluid strats to a bearing on rock or some other firm stratum, while if they are placed in fairly hard ground without reaching any impenetrable bottom stratum, but where the friction between their surfaces and the penetrated ground is sufficient to sustain the load safely they are said to act through skin friction.

Timber Piling

Timber piling is in general use for bridge and culvert foundations, for bents of temporary and permanent wooden trestle bridges, for falsework and emergency repairs. Piles preferably are made from tall, straight, slightly tapering tree trunks of any structural timber, etc., although falsework piles are made of almost any sound timber not too weak to endure driving. While foundation piles have indefinite underwater life and are known to have lasted over 1000 years under the Campanile in Venice, they are short lived above water, lasting sometimes only 3 to 4 years owing to ravages of fungi, worms or marine borers. They are frequently treated with chemical preservative as a protection

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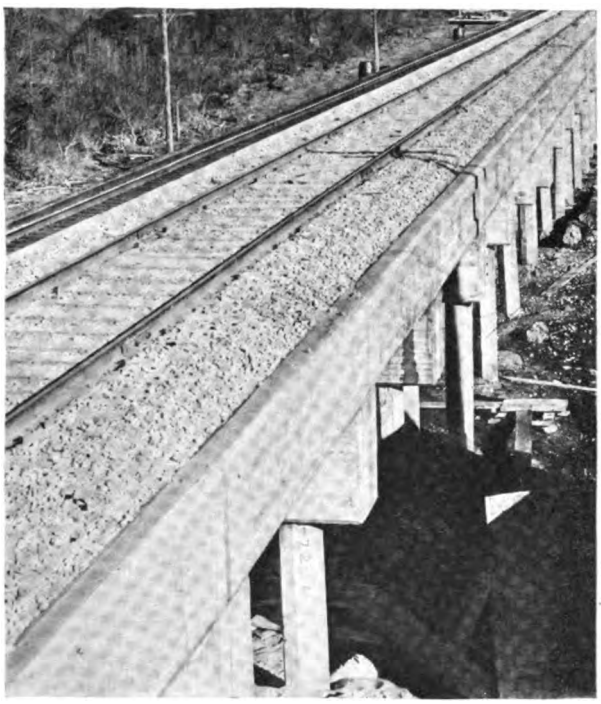
against decay while piles in wharves, etc. in salt water are commonly treated with creosote. In some cases they have been encased in earthware tile with a layer of sand or concrete between to prevent destruction by wood borers.

Square timber piles sometimes used for sheet piling are rarely used for other purposes. Ordinarily timber piles vary from 20 ft. to 50 ft. long with butts 10 in. to 16 in. in diameter and points 7 in. to 9 in. across. A slender pile drives best in hard ground, while a large pile is most valued in softer material where skin friction is the chief support. The short life and growing scarcity of trees for timber piles have influenced the use of concrete as a more permanent material for piling.

Concrete Piles

Concrete is readily adaptable to the construction of heavily tapered piles, which develop, on account of this form, about twice the bearing power of wooden piles, which are commonly restricted to loadings of 10 to 20 tons each. Whereas wooden piles are permanent only below the water line, concrete piles are not so restricted, enduring as well above the ground, thus saving excavation and height, weight and cost of superstructure. They cost more than wooden piles and require more careful handling on account of their relatively restricted resiliency. Concrete piles cannot be driven so quickly as wooden piles, but fewer are needed and their durability is an important factor, their strength increasing somewhat with age, while in salt water they are not subject to destruction by wood borers as are timber piles. They are frequently made 50 to 60 ft. long and have shown remarkable resiliency in wharves and docks where this characteristic is of prime importance.

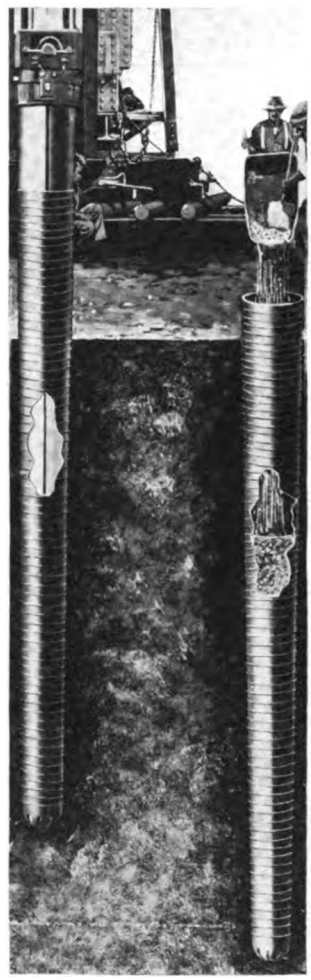


Trestle on Pre-Molded Concrete Piles

Concrete bearing piles are classified as (1) pre-cast and (2) cast-in-place. Pre-cast piles are made of reinforced concrete. In form they are similar to bearing piles of other materials, being square in cross section with beveled corners, or octagonal, hexagonal, or round, with or without a taper. Some kinds are molded to vary the cross section with a view to increasing frictional resistance, or with a hole or holes designed to facilitate the use of water jets.

A cast-in-place concrete pile is built in its permanent place in a hole made for the purpose. One method is to hammer-drive a collapsible steel core fitting snugly inside a tapered sheet casing which is provided with a solid steel point. When the casing is in place the core is withdrawn, after which the watertight casing is filled with concrete. Others are formed by first driving a steel pipe with a removable shoe and gradually filling the hole with concrete as the pipe is withdrawn permitting the concrete to flow through it. A pile with a bulbous base is made by first driving a steel core which is fitted inside a pipe and which has a flanged head engaging the top of the pipe while its point extends beyond the lower end of the pipe. After the core and pipe have been driven together into the ground the core is withdrawn, a batch of concrete is placed in the pipe and the core is used as a rammer to enlarge the hole below the pipe by crowding the con-

Mushroom Concrete Piling
The MacArthur Concrete Pile & Foundation Co.
(See Page 741)



Construction of Raymond Cast-in-Place Concrete Piles
The Raymond Concrete Pile Co.

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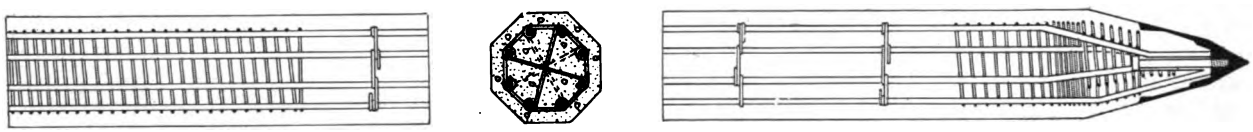
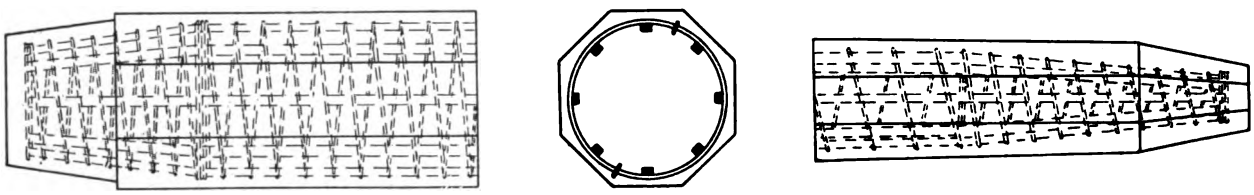
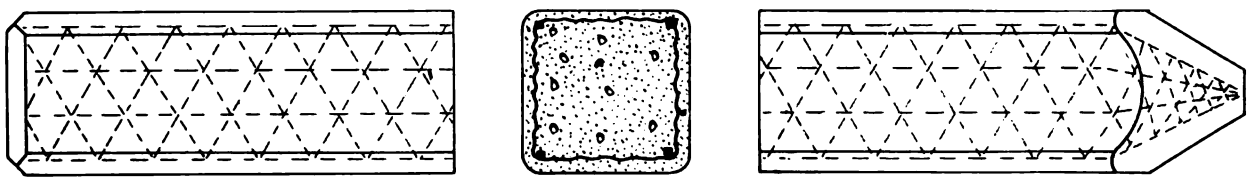
crete out to all sides to the desired extent, when the bulbous base thus formed as well as the pipe are filled completely with concrete, after which the pipe is withdrawn leaving the completed pile in the ground. When casting piles in place, care is taken that the concrete of the first pile is well set before the hole is made for another close to it, as the force employed tends to crowd the earth displaced from the second hole into the soft concrete of the first, and the vibration from the hammer blows may



Concrete Pile, Pennsylvania Railroad



Concrete Pile, Chicago, Milwaukee & St. Paul



Concrete Pile, Chicago, Burlington & Quincy

also injure the green concrete even if it is protected by a steel casing. When a cast-in-place pile is to be reinforced, it is considered good practice to place the fabricated reinforcement in position as a unit, prior to pouring the concrete.

Sheet Piles

Sheet piling made of timber, metal or pre-cast reinforced concrete shapes are in general use to enclose areas from which water is to be excluded during the construction of foundations, etc. The sheet piling resembles dressed and matched lumber driven end-wise into the ground with edges interlocked, making a water-tight wall around the foundation site, so that the water may be pumped out of the enclosure and the work done as on dry land.

Wooden sheet piling is made in various forms, an effective and much used kind being the Wakefield, consisting of three boards of equal width bolted flatly together as a three-ply timber, the edges of the outside boards being even while the middle board is set to one side so that one edge protrudes, forming a tongue while the others, being inset, form a groove. The piles are sometimes chisel pointed and are driven closely edge to edge with tongues and grooves of adjacent piles engaged to complete the joining. The same effect is obtained by using a sheet pile made of a single thicker timber with manufactured mortise and tenon joints, or by using plain planks driven singly to form a wall of two or more thicknesses, the planks in adjacent thicknesses breaking joints vertically. Plain board piles are sometimes furnished with dovetailing edge-strips of hard wood, the total width of three dovetailed strips assembled being equal to the thickness of the pile. To facilitate joining, the middle dovetail strip is tapered for a few inches at the bottom so that it may be started readily between the two strips on the edge of the adjacent pile. Timber sheet piling is commonly made of 16 ft. dressed plank 2 in. to 4 in. thick, the finished walls being sometimes 12 in. thick. Difficulty is often experienced in driving such piling straight into hard ground or into soft ground containing such obstacles as boulders, sunken logs, etc. Excavation is sometimes necessary to remove the obstacles, for the piles must be driven with exactness to form a water tight wall, and with care to prevent brooming the tops, splitting the planks or injuring the joints. These and other limitations as to length, etc., led to the design of lock joint steel sheet piles.

Metal sheet piles are commonly rolled steel shapes with interlocking edges such as alternately hooked channels, z-bars, modified I-beams (with hooked flanges used as connections for larger I-beams placed flange to flange,) or over-lapped corrugated steel sheets. These types are symmetrical throughout the length of the piece, are not pointed, are available in long lengths, may be spliced readily, driven pulled and redriven several times, even the rough usage of driving among boulders and through soft rock strata affecting only the ends which can be sawed off with small loss. These types however vary considerably in stiffness, in the strength of the joints and in resistance to flexure. Steel sheet piling is largely used for coffer dams for bridge and building foundations.

In the construction of water terminals, sheet piling sometimes is employed as a part of the permanent structure. The pieces are, in effect, concrete

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boards which are reinforced and driven by means of water jets. Some are chisel pointed, and either rectangular in cross section or with tongues and grooves on the edges, or with semi-circular grooved edges, the adjacent grooves forming a round hole utilized as a channel for the water jet pipe to be filled with grout after driving. These piles are usually not less than 8 in. and frequently 12 in. or more in thickness, sometimes as large as 18 in. by 18 in. by 50 ft. and are reinforced with trussed steel rods. Combinations of steel interlocked joints with concrete piles have been used in some instances where permanent construction and the inter-locking features both were desired. The employment of concrete sheet piling is restricted to cases where the walls of piling form a part of the permanent structure. See Pile Driver.

PILE, BATTER. A pile driven at an inclination to resist forces other than vertical.

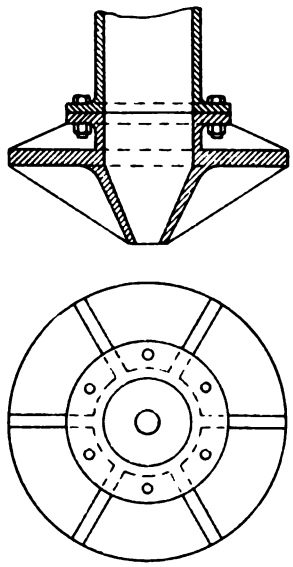
With a view to obtaining stability in pile bents, the outside piles are usually battered at a slope not exceeding 3 in. horizontal in 12 in. vertical. In the fabricating of steel bridge bents, the outside member like those of a pile of frame bent, are battered, the batter being from 1 in. to 3 in. horizontal in 12-in. vertical. The general principle of stabilizing such structures by broadening their bases is especially important in railway design because of the vibration caused by rolling loads, etc. In order to drive piles on a batter the leads of the driver must be inclined, and for this purpose modern railway pile driving machines are so constructed that the leads may be inclined while the base remains horizontal. See Pile Driver. Also Pile.

PILE, CONCRETE, CAST-IN-PLACE. A pile which is formed by casting it in a hole in the ground. The hole for casting is commonly prepared by driving and removing a metal form or mandrel or both. See Pile.

PILE, CONCRETE, PRE-MOLDED. A pile which is cast in a form previous to being driven. The mold is usually collapsible and is placed horizontally on skids where it is left under the newly cast pile while the concrete is hardening. See Pile.

PILE, DISC. A pile having a flat circular metal disc usually of cast iron, attached to its foot to increase its bearing area. Its use is restricted to wet shifting sand or other unstable strata.

Generally a disc pile consists of a hollow sectional wrought iron shank on or near the bottom of which the flat disc is keyed or bolted. A common size of disc is 2 ft. in diameter and 8 in. thick. Disc piles are driven by means of a water-jet, the water being forced down through the hollow shank and out at the base through a hole in the center of the disc. See Pile.

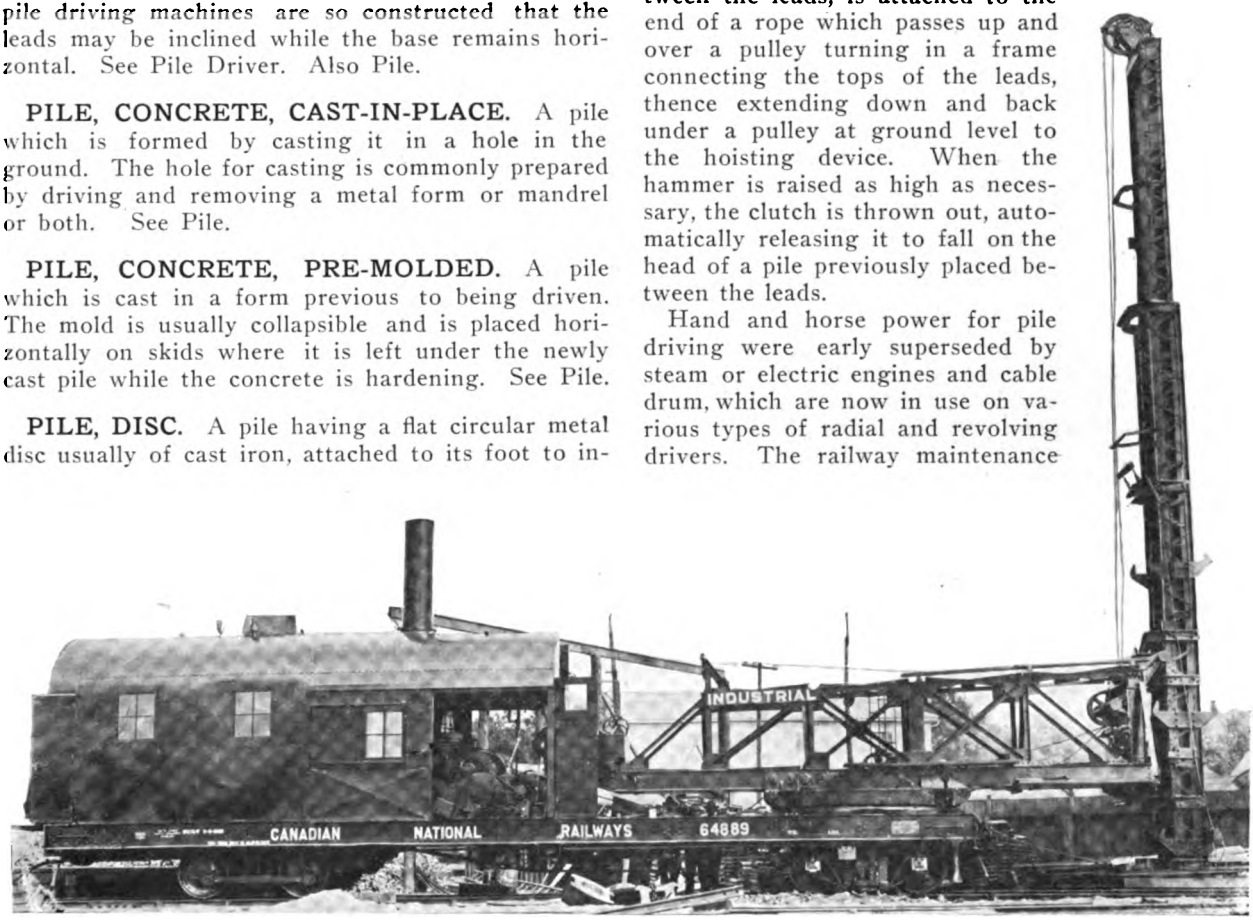


Disc Pile

PILE DRIVER. A machine for driving down piles, usually a large frame with appliances for raising to a height and releasing a heavy block which is dropped on the pile.

A common type of wooden pile driver consists of two diagonally-braced parallel upright timbers or leads overhanging the forward end of a rectangular base of four wooden sills. The hammer, sliding in grooves between the leads, is attached to the end of a rope which passes up and over a pulley turning in a frame connecting the tops of the leads, thence extending down and back under a pulley at ground level to the hoisting device. When the hammer is raised as high as necessary, the clutch is thrown out, automatically releasing it to fall on the head of a pile previously placed between the leads.

Hand and horse power for pile driving were early superseded by steam or electric engines and cable drum, which are now in use on various types of radial and revolving drivers. The railway maintenance



Heavy Duty Pile Driver. The Industrial Works

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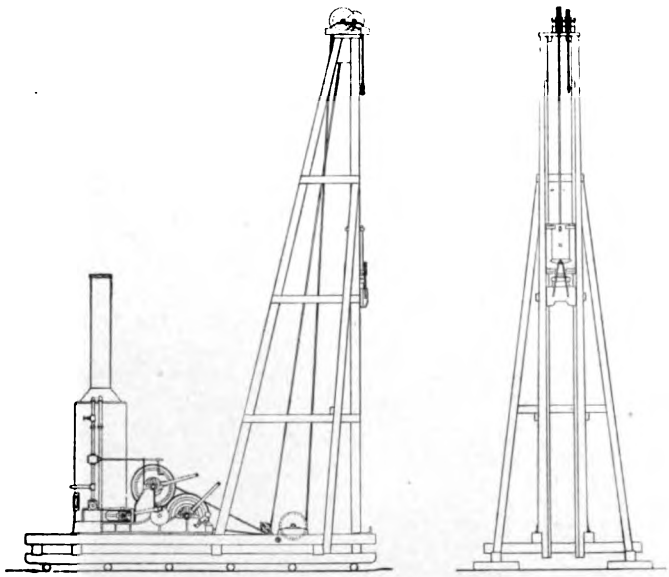
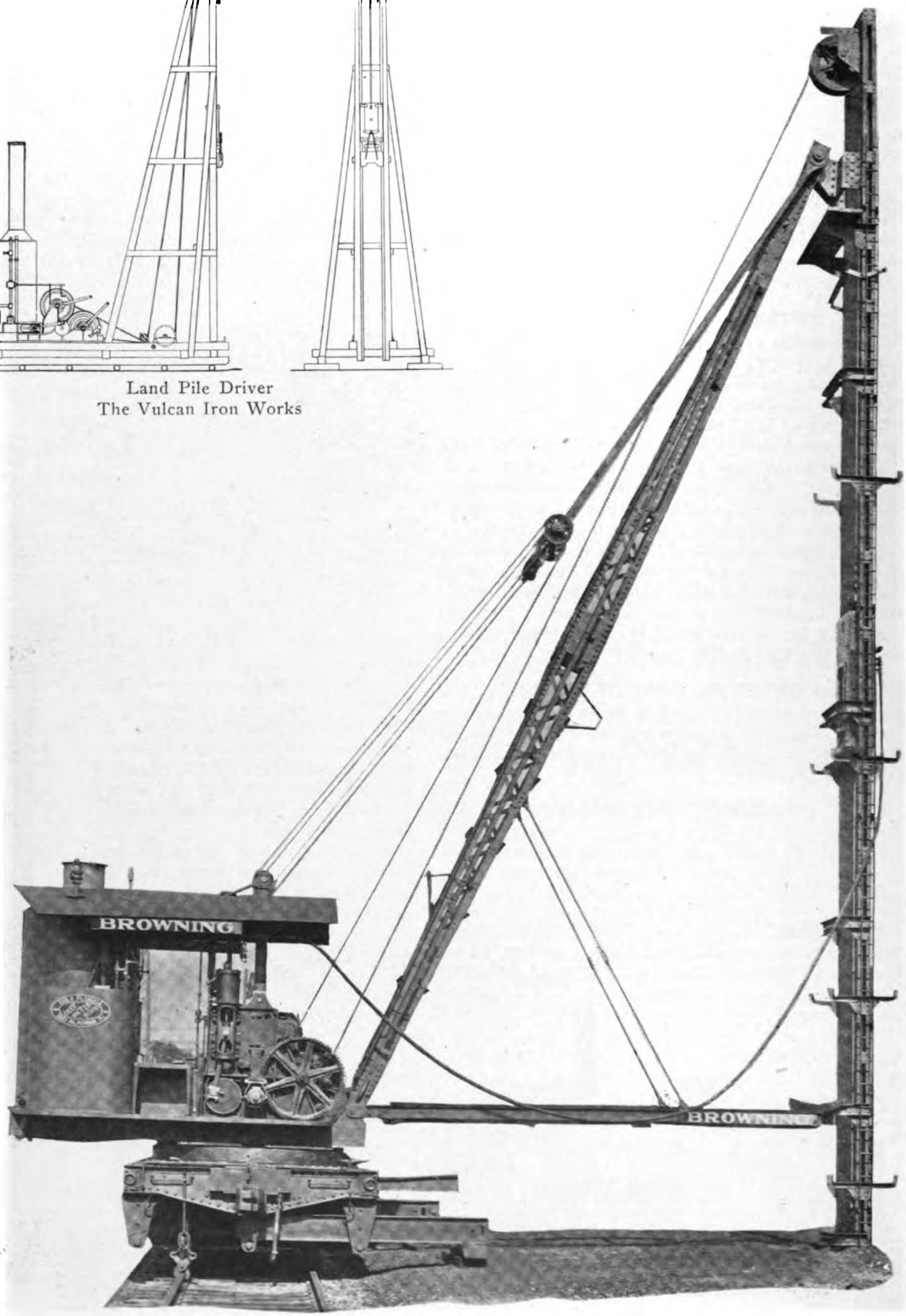


Land Pile Driver
The Vulcan Iron Works



Locomotive Crane Pile Driver. The Browning Co.

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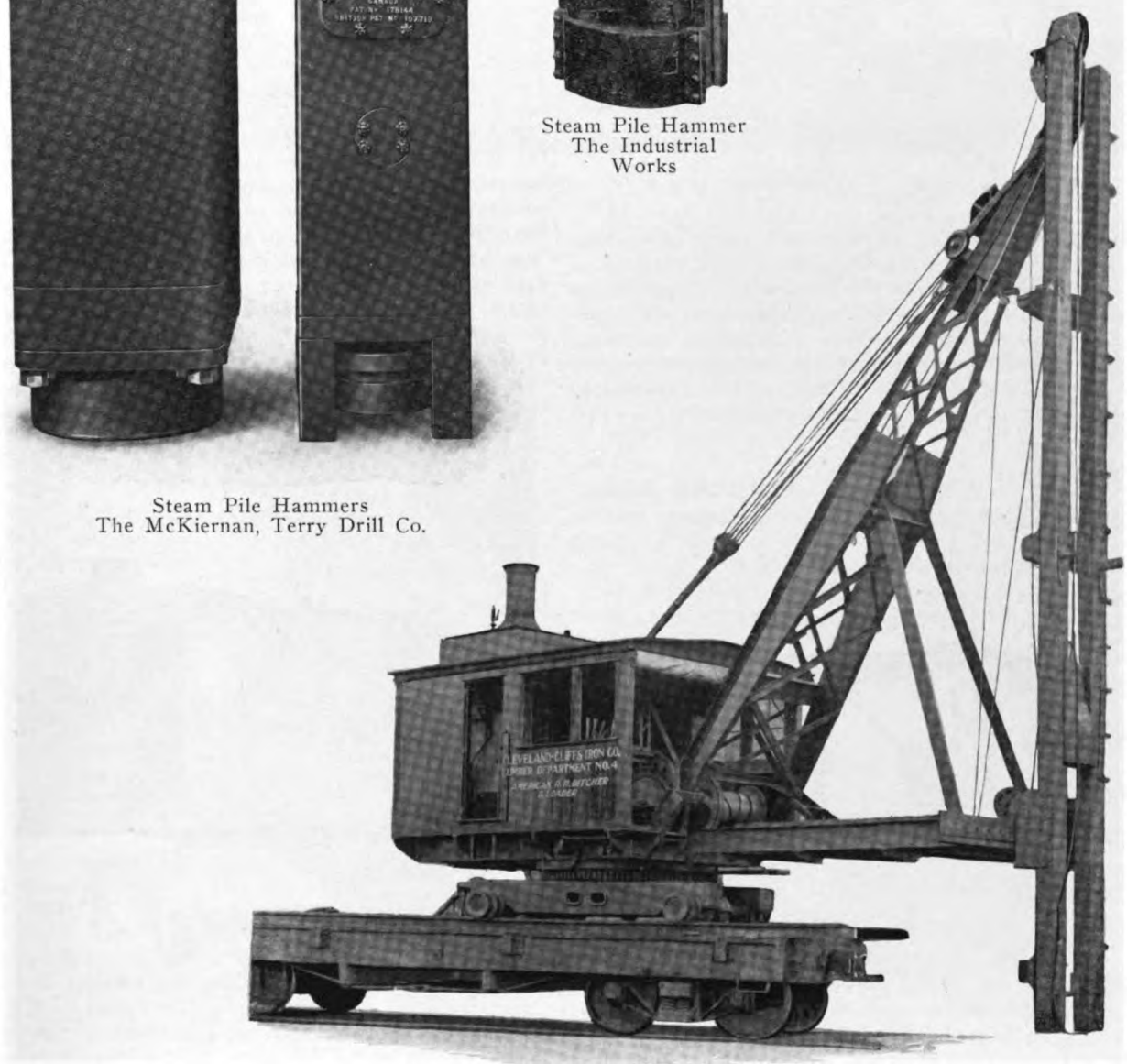
Steam Pile Hammers
The McKiernan, Terry Drill Co.

Steam Pile Hammer
The Industrial
Works

Drop Hammer
The Vulcan Iron Works



American Ditcher, with Pile Driver Attachment
The American Hoist and Derrick Co.

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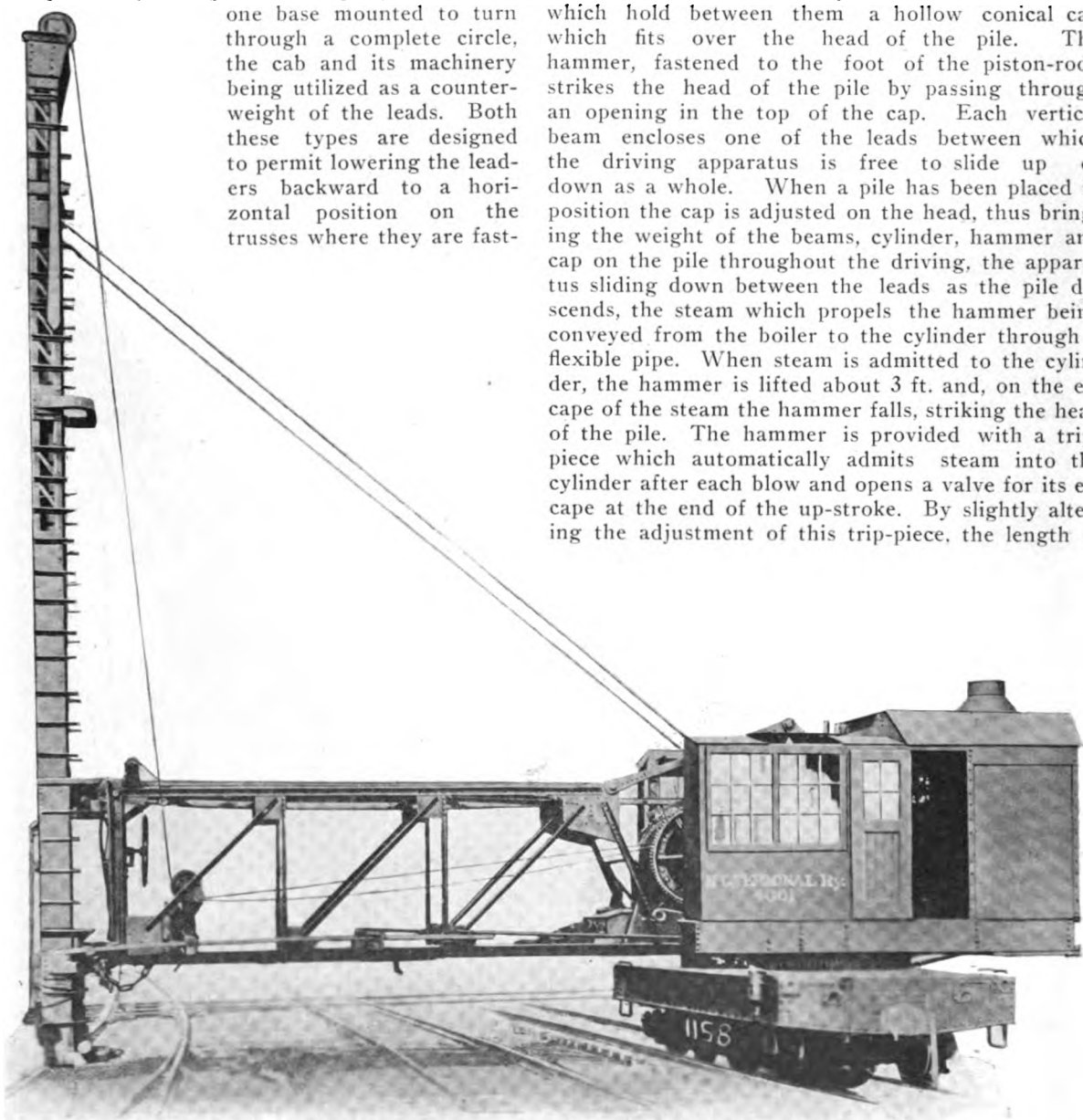
pile driver usually has leads hinged to the front end of a trussed framework which may be extended or revolved in a horizontal plane on a turntable carried over the front truck. The movable framework, usually of steel, is located at the forward end of the car, while the steel hammer of 2000 lb. to 3500 lb. weight is operated at the end of a cable winding around a horizontal hoisting drum turned by a hoist which is housed in a cab at the rear of the car. The horizontal trusses rest on a carriage which may be extended for driving piles vertically or on a batter at about 12 ft. to 20 ft. on either side of the center line of the car. Radial pile drivers have trussed lead frames that can be turned to either side at right angles to the center line of the car while the power and operating devices remain stationary. The revolving type has the power, operating and driving apparatus all on one base mounted to turn through a complete circle, the cab and its machinery being utilized as a counterweight of the leads. Both these types are designed to permit lowering the leaders backward to a horizontal position on the trusses where they are fastened when the machine is made ready to move by train. A pile driver of this class is usually fitted with a self-propelling chain drive designed for speeds of five miles or more per hour to allow of side track movements to pass trains, etc., a valuable feature for a machine used on heavy traffic lines. Various types of revolving steam shovels, locomotive cranes and ditching machines are also used to drive piles, for which purpose the dipper arm is removed and pile driving leads hung to the end of the boom. Hammers are also dropped from the ends of booms without leads, being held in position with guy lines.

A further development of the pile driver is the steam hammer which consists of an upright steam cylinder confined between the upper ends of two upright parallel I-beams or channels 7 ft. to 15 ft. long and about 18 in. apart, the lower ends of which hold between them a hollow conical cap which fits over the head of the pile. The hammer, fastened to the foot of the piston-rod; strikes the head of the pile by passing through an opening in the top of the cap. Each vertical beam encloses one of the leads between which the driving apparatus is free to slide up or down as a whole. When a pile has been placed in position the cap is adjusted on the head, thus bringing the weight of the beams, cylinder, hammer and cap on the pile throughout the driving, the apparatus sliding down between the leads as the pile descends, the steam which propels the hammer being conveyed from the boiler to the cylinder through a flexible pipe. When steam is admitted to the cylinder, the hammer is lifted about 3 ft. and, on the escape of the steam the hammer falls, striking the head of the pile. The hammer is provided with a trip-piece which automatically admits steam into the cylinder after each blow and opens a valve for its escape at the end of the up-stroke. By slightly altering the adjustment of this trip-piece, the length of



Pile Driver. The McMyler Interstate Co.
(See Page 744)

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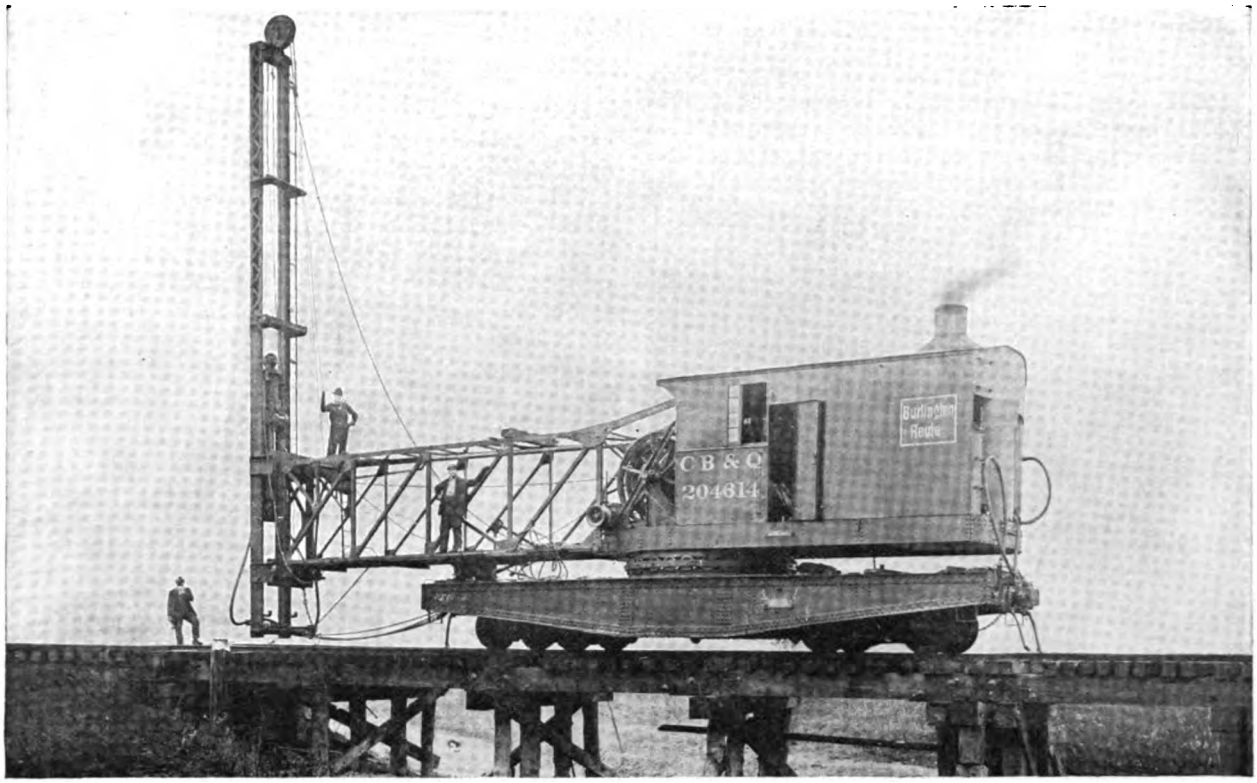

Locomotive Pile Driver. The Orton & Steinbrenner Co.

stroke may be increased or diminished, the admission and escape of steam to and from the cylinders regulating the number of hammer blows per minute. This steam device may also be double acting, in which type the force of steam also accelerates the fall of the hammer, increasing the force of the blow and the number of strokes. The chief advantage of this device over the ordinary type of pile driver lies in the addition of the dead weight of the apparatus and the impetus of steam to the force of the blow and the rapidity of action which allows little time for the disturbed particles of earth about the pile to recompact around in sides or under its foot. This hammer can be applied to any type of pile driver.

Broomed Timber Pile

Where penetration is difficult as in quick sand, the hammer is frequently supplemented by a water jet forced through a pipe placed beside the pile and ending near the point. The water, emitted under pressure from pipe, softens and churns the ground around the pile which descends into the hole thus made, usually under the dead weight of the hammer set on the head to follow it down. A water jet is an accessory applicable to any style of pile driver. A further development of this idea is embodied in some designs of concrete piles in which the water pipe or pipes are incorporated in the pile itself. See Pile. Also Water Jet.

PILE, BROOMED. A timber pile with the tip or butt mashed by excessive driving, which crushes the wood fibers.

In many cases piles are driven so hard that the points first broom and then break, severely injuring the bottom portion of pile. There is usually more danger of driving piles too hard than not hard enough, especially when the work is under inexperienced supervision. See Pile.

PILE, FENDER. One of a cluster or number of piles driven in front of exposed pier nosings and other important structures to protect them from injury due to blows from vessels, etc.

PILE, FOOT OF. The lower end of a pile, usually but not always the top or small end, piles being sometimes driven butt foremost.

PILE, GUIDE. A pile used to restrict the movement of a structure, as the four guide piles frequently driven at the corners of a rectangular timber crib in order to sink it to the required spot to serve as a form for an under-water concrete foundation as of a bridge pier. See Pile.

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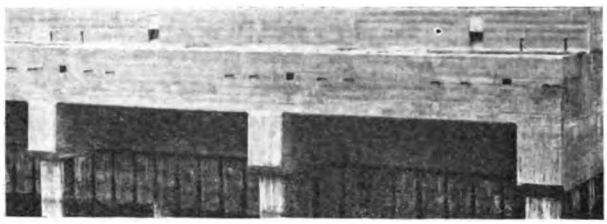
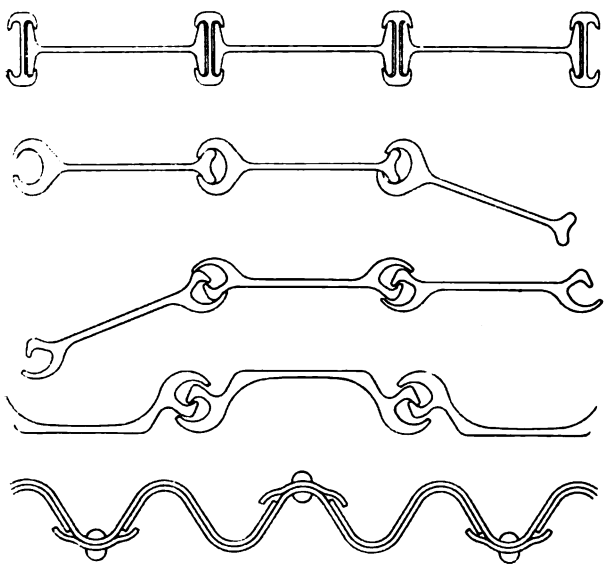
PILE, LAGGED. A wooden pile which has timber blocks fastened to its side surfaces with a view to increasing its bearing power.

PILE, SHEET. An upright member of a tight board fence about an enclosure, the bottom of which is under water as in a cofferdam. Sheet piles are made of wood, metal or reinforced concrete in the shape of flat beams with interlocking edges with a view to forming water tight boundary walls. See Pile.



Typical Concrete Sheet Piling



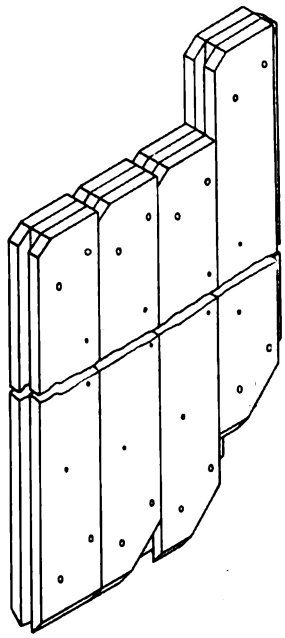
Steel Sheet Piling Shapes
The Lackawanna Steel Company

PILE, TEST. A pile driven to ascertain the bearing power of the soil or its comparative resistance in order to judge the lengths and number of piles which should be used in a structure.

PILE TRESTLE. A structure in which the upright members or supports are piles. (A. R. E. A.) See Trestle Bridge.

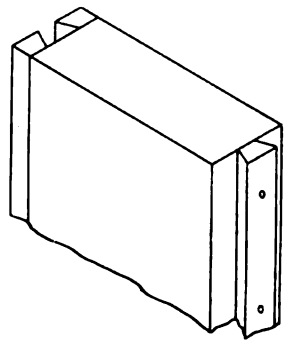
PIPE (Culvert). One of a line of short tubes carried under a railway roadbed to form an artificial passageway for water, etc.

Culvert pipe is made of earthenware tile, of reinforced concrete, of pure iron, or sheet steel or of cast iron, usually circular in section, and in lengths of 2 ft. to 12 ft. Most of these pipes have bell and spigot joints although tongue and groove joints are commonly used in concrete, while lock and flanged joints are used in metal pipe as well as the lap joint which is a recognized standard in the corrugated and galvanized pure iron types. It is considered good practice to lay railway culvert pipes of sizes large enough to permit a man to go through and free the waterway from obstructions, the minimum desirable diameter being two feet, while pipes as large as five feet in diameter are common and some of seven feet diameter are used with a view to



Wakefield Wooden Sheet Piling

Timber Sheet Piling



Wood Cleat Sheet Piling

Concrete Sheet Piling
The Raymond Concrete Pile Co.

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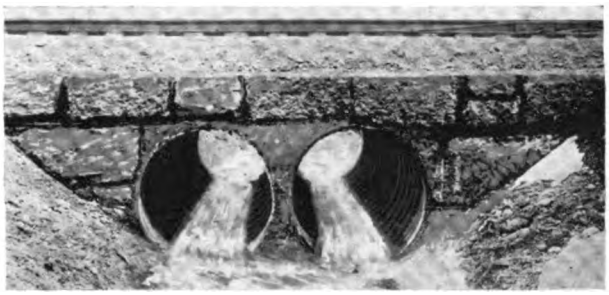
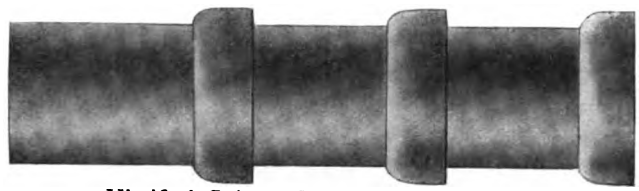
serving secondarily as cattle passes. The foundations for pipe culverts, especially under high embankments, are laid to a slight vertical curve or camber to allow for settlement, the extent of the camber depending on the character of the foundation soil as well as on the weight over the pipes. In wet sandy soils a camber of about 8 in. has been found suitable for pipe 48 in. diameter under embankments 40 ft high. In some cases it is necessary to



Armco Culvert with Masonry Head Wall
The American Rolling Mills Co.
(See Page 638)

place the pipes on masonry slab foundations, as when rock outcrops are encountered or when parts of the line of pipe cross narrow areas of yielding soil, such as sections of old creek or swampy ground. The laying of culvert pipe is started from the upstream end, the lengths being laid with bell ends upstream. If possible the water is diverted while the pipe is being laid, the back fill well tamped about it on both sides and the fill constructed to a height well above the surface of the water. A cushion of earth a foot or more in thickness is preferably placed over the top of the pipe before the embankment is completed, especially if the material is being plowed off a train from a height, as from a bridge. It is considered good practice to lay culvert pipe at least one diameter below subgrade to avoid too heavy concentrations. The inlet and outlet of a pipe culvert are sometimes provided with end walls or facings placed parallel with the track to retain the slope of the embankment and to protect the pipe from the scour of the water, although wing walls at 30 deg. angles to the axis of the pipe will increase its capacity perceptibly. The footings of facing walls should extend well below the stream bed into reasonably solid material. See Culvert.

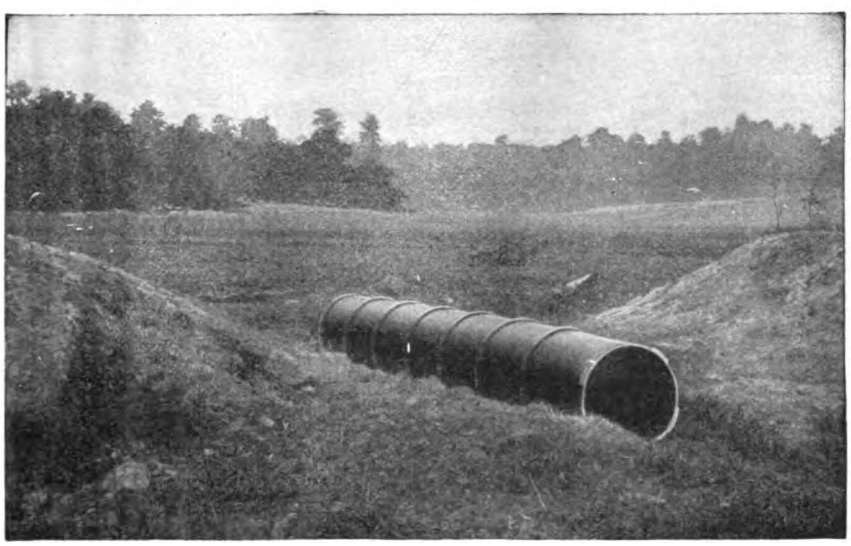
PIPE, CULVERT, EARTHENWARE. A tube of burnt clay, usually circular in section, made in short lengths to facilitate handling and designed to be laid end to end to form underground waterways under railway embankments, highway crossing approaches, etc. See Culvert.



Vitrified Culvert Pipe with Bell End
The Blackmer & Post Pipe Co.

PIPE CULVERT, METAL. A line of cylindrical or sectional iron or steel pipe usually 12 ft. or less in length and 5 ft. or under in diameter, joined together with suitable joint devices to form a passageway for water, etc. See Culvert.

Cast Iron Culvert Pipe with Concrete Head Wall
The American Casting Co.
(See Page 631)



Cast Iron Lock Joint Culvert Pipe
The American Casting Co.
(See Page 631)

An 18-in. Armco Corrugated Iron Culvert
The American Rolling Mills Co.
(See Page 638)

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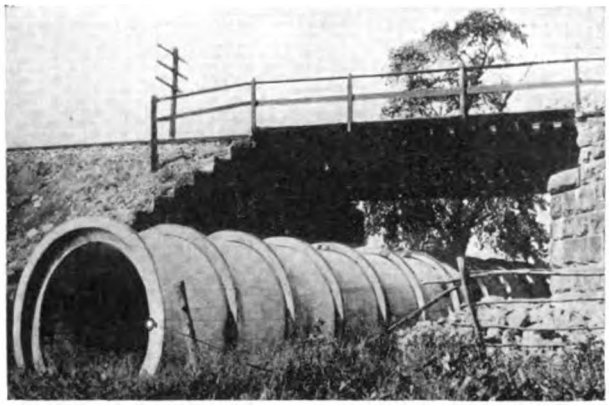
PIPE, REINFORCED CONCRETE CULVERT. A monolithic concrete tube usually cylindrical, reinforced with metal rods or wire mesh and designed to be joined together to form a smooth and continuous passageway for water, etc.

While commonly molded in circular or oval sections, it is sometimes triangular with rounded corners. When used as culvert pipe on railways it is generally made 8 ft. long for sections having inside diameters of 5 ft. and under, and 6 ft. long for sections having inside diameters of greater than 5 ft., while those of diameters less than 2 ft. are commonly furnished in lengths of 2 and 2½ ft. The amount of



A Concrete Pipe Culvert
The Massey Concrete Products Corporation
(See Page 743)

reinforcing varies with the thickness of the pipe, its diameter and the weight it is designed to support. Pipe which has walls 5 in. or less in thickness usually is reinforced with one ring of fabricated metal bars or mesh or a combination of both to form a cage, while pipe which has walls greater than 5 in. in thickness may have two concentric rings of reinforcement. The small diameter pipes commonly

Reinforced Concrete Culvert Pipe
L. S. Gelser & Sons, Inc.

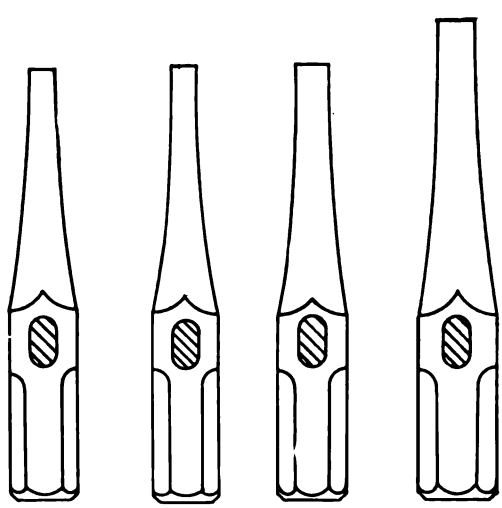
have bell and spigot joints, but those of the larger diameters sometimes have tongue and groove joints. Since there is commonly some settlement of material over a railway culvert, it is generally considered good practice not to seal the joints as the sealing will usually be cracked or broken. Masonry head walls or wings are sometimes placed at the ends of concrete culvert pipe to prevent securing and to retain the slopes. When there is a constant flow of water through a culvert it is good practice to use wing walls also to prevent possible water scouring back of the ends and along the pipe during high water and to increase the effective capacity of the pipe. Additional protection is afforded by paving the floors of approaches, paving of loose rock or a concrete apron, the top surface of which is slightly below the grade line of the pipe, placed between the wings in front of the inlet and outlet forming an effectual method of preventing scouring beneath the pipe. Culvert pipe of triangular section while not as common as other types, is sometimes used where the headroom between the bottoms of the ties and the top of the pipe is restricted. They are used on some railways instead of open box ballast drains, the pipes being designed to be laid on any one of the three sides and connected together by means of bell and spigot or tongue and groove joints. Reinforced concrete pipe used by railways for culverts seldom is less than 18 in. or more than 48 in. in diameter, although when used as cattle passes the diameters are sometimes as great as 108 in., a flat surface about 2 ft. wide at the bottom serving as a walk. See Culvert.

PLATE, BATTEN. A rectangular steel plate used to supplement the lacing bars in providing the requisite strength to the open side of a built-up bridge member.

Batten plates are laid flat across the outside of the members, near the ends and sometimes at intermediate points, and are riveted to the flanges. A batten plate of a main bridge member is usually specified to be as long or longer than the distance between the inside lines of rivets connecting it to the flanges, while an intermediate batten plate must be half as long. The batten plates are used where the lacing is interrupted. See Bar, Lacing.

PORTAL BRIDGE. The overhead sway bracing connecting the end posts to the terminal top strut of a through truss bridge. See Bridge.

PUNCH, BACKING OUT. An iron workers hand hammer punch used to remove rivets from



Backing Out Punches

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steel plates, etc., after the heads have been cut off.

A backing out punch commonly consists of a blunt pointed, tapered working end which terminates a rectangular sectioned shank and hammer head. A central eye located near the head of the tool and passing through the shank permits the use of a wooden handle by which the device is held while being struck a blow with a maul. See Rivet Buster.

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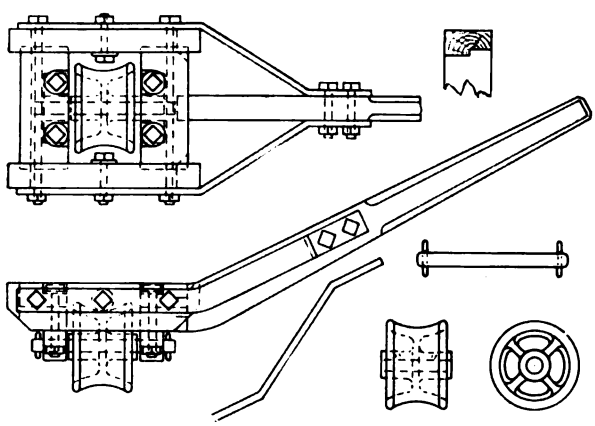
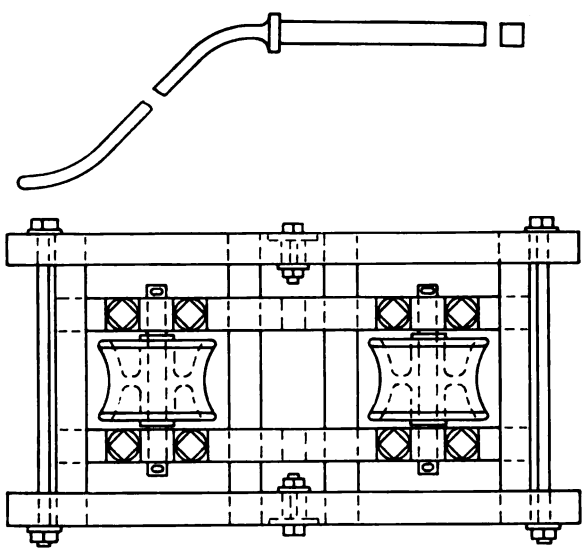
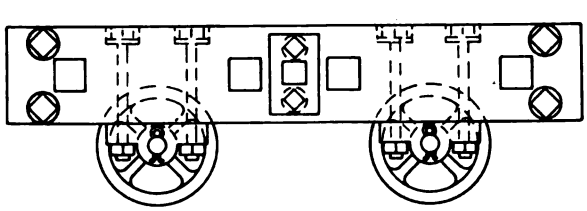
RAIL JACK. A small single or tandem wheeled vehicle with a hollow flange made to run on a tee rail.



Rail Jack





Double Rail Jack

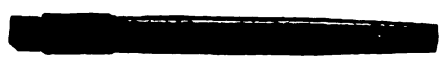
Rail jacks, sometimes called rail dollies are commonly used by bridge erectors to move loads too heavy to carry by hand. This tool is similar to a timber dolly except that the wheel is of a narrow skeleton type about 7½ in. in diameter which has a concave tread designed to fit the ball of a rail. It has a heavy hardwood frame or platform on the bottom of which is fastened the centrally located wheel, the axle of which revolves in metal boxes usually bolted to the bottom of the outside members of the frame. A bar extending at right angles from the side of the frame provides a means of moving the vehicle with its load along the rail. The frame of a rail jack is usually about 13 in. long and 16 in. wide, though when equipped with two tandem wheels the width is as much as 18 in. while the length is about 3 ft. Rail jacks are commonly used by bridge gangs to transport bridge timbers or steel work on the running rail during the erection of the bridge. See Dolley (Timber).

RAIL LOCK, MOVABLE BRIDGE. A device designed to form a safe joint at the ends of the adjacent movable span rails and shore rails when the bridge is closed, and to release the rails readily when the bridge is to be opened.

The rails may be cut square with the ends far enough apart to allow for the maximum expansion, while the wheel treads are carried over the joint on sliding sleeves or on easer rails placed against the outside of each running rail, the flanges being guided by guard rails, or they may be beveled or riveted at the ends. Sleeves and easer rails are preferably made of manganese steel and are raised a fraction of an inch above the running rails to protect the ends from battering. The rail locks are operated by plunger rods or similar devices controlled by the bridge operator from a tower above the tracks in the middle of the movable span. See Bridge.

REAMER. A steel tool designed to true or enlarge holes in wood or steel to facilitate the passage of bolts or rivets.

A common type of reamer consists essentially of a straight cylindrical steel shank terminating at the



Bridge Reamer

Bit Stock Taper Reamer

contact end in a cutting portion generally formed by fluting and sometimes also by tapering the cylindrical shank to a sharp angular section, usually triangular, square or pentagonal. The head of the tool fits in a depression in the chuck or handle. Reamers are usually designed to ream holes ⅛ in. or more in diameter, the smaller sizes being commonly used for rivet holes, while the larger tools up to about 2 in. in diameter are used to ream the inner surfaces of metal pipe to receive threads.

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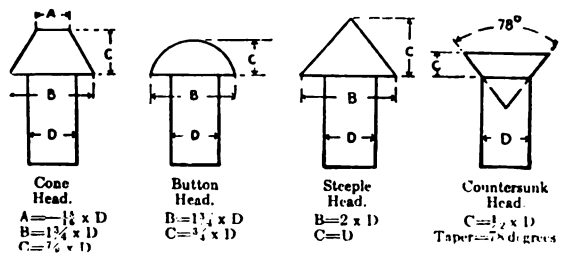
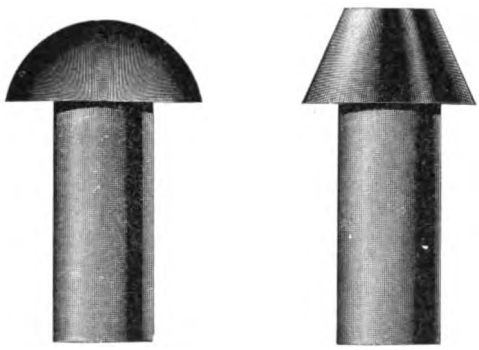
REFUGE BAY. A rectangular platform with a railing around three sides erected at one side of the track on a long bridge as a place of safety for employees while trains are passing. Refuge bays are built on cantilever beams, such as long bridge ties or special girders, or on members extending from the side of the span and braced from beneath. Space is usually provided to accommodate a hand car and several men. These structures are frequently placed from 500 ft. to 1000 ft. apart, alternately on the right and left sides of the bridge.

RIVET. A short metallic malleable bolt designed to pass through a hole and be so fastened as to keep pieces of metal, or sometimes other substances, together.

The fastening which distinguishes the rivet is the enlarging and flattening of the point into a head after insertion. Rivets in steel structures are usually hammered or pressed while red hot, so as to draw the pieces more firmly together by the contraction of the rivets in cooling. See Riveting.



Proportional Dimensions of Rivet Heads



Boiler and Structural Rivets

RIVET BUSTER. A tool used to cut off the heads of rivets. A rivet buster commonly consists of a flat, wedge shaped cutting portion and a rectangular shank and beveled edged hammer head. The cutting portion terminates in a chisel-like cutting edge while the shank has a central eye to permit the insertion of a wood handle by which the tool is held while being struck with a maul. The rivet buster is used to remove the heads while a backing out punch is used to remove the rivet. See Punch, Backing Out. Also Riveting.

Rivet Buster

RIVET HAMMER (Hand). A one faced hammer designed for driving rivets.

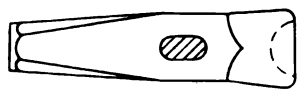
The head of a rivet hammer is usually made of a single piece of special tool steel, the pein is chisel pointed, the pole is plain with a slight taper, and the face is circular or sometimes octagonal. A rivet hammer suitable for bridge maintenance work weighs about 5 lb. The straight hard wood handle is about 18 in. long. See Rivet. Also Riveting.

RIVET PITCHING TONGS. Tongs used by forge-tenders or blacksmiths to toss hot rivets to a riveting crew.

Rivet pitching tongs consist essentially of two light steel rods working scissors-fashion on a pivot to form short, flat tapering jaws and long rounded handles. The end of one jaw is cupped to receive the shank of the rivet while the opposite jaw is straight throughout its length to hold the rivet in place as the handles are pressed together. As the rivet is released, the handles are pulled apart, the rivet dropping to the straight jaw and being released from the tool with a pitching motion. See Rivet. Also Riveting.

RIVET SET. A special hand hammer used to shape the head of a rivet under blows from a maul.

A rivet set consists essentially of a circular steel pein and a rectangular shank and hammer head. The working face of the pein is equipped with a cup-like receptacle which shapes the head of the rivet while an eyelet passing through the shank permits the attachment of a wood handle by which the tool is held in position. See Rivet. Also Rivet Hammer (Hand). Also Riveting.



Rivet Set

RIVET STICKING TONGS. Tongs used to place rivets in the rivet holes of structural members.

This tool is similar to rivet pitching tongs except that the jaws are bent upward while the ends are oppositely cupped to grasp the shank of a rivet and place it in the rivet hole. The jaws of a rivet sticking tongs are bent upword at an angle of about 45 deg. from the plane of the handles to enable the rivet handler to place the rivet squarely in the rivet hole when the jaws are flat against the structural member. See Riveting.

RIVETER. A man or a machine employed in fastening rivets into place by clinching the points and forming them into heads. See Riveting.

RIVETING. The act or method of joining with rivets.

Riveting is accomplished primarily by means of compression of the rivet endwise by hand or machine power. Severe compression of a red hot metal rivet causes the shank to expand until it fills the rivet hole, thus holding the metal plates or pieces more

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firmly in position. The correct temperature of the rivet while being compressed is important, for overheating distorts the shape of the rivet and unless the metal is hot enough when hammered it cannot be made tight. Field riveting is not approved if the work can be done in the shop where hydraulic or pneumatic pressure riveting machines and convenient forges permit the best riveting to be done rapidly.

The act of field riveting consists usually of forming a button-like head of the pointed end against the flat metal surface around the hole, by hammering the protruding red hot point after it has been thrust through the rivet hole while the manufactured head at the other end of the rivet is held firmly against the metal on the opposite side of the joint. This holding is now frequently accomplished with a compressed air tool called a holder-on though usually a hand maul, a holding bar called a dolly and a head forming tool called a rivet set are used.

Pneumatic field riveting requires air compression and delivery of compressed air, bolting and drifting reaming rivet holes, heating rivets, passing heated rivets from the forge to the placer, putting heated rivets through the holes, backing up the heated rivets in place and hammering the joints into rivet heads.

Methods of bridge erection and of handling connections of bridge members bear directly on field riveting, which is done entirely with the hammer. Schemes may readily be worked out to avoid close corner field riveting on new work or extensive bridge alterations. On small work, such as reinforcing bridges under traffic or in place, renewing members of steel water tank supports, ferry boat transfer tables, track scales, building trusses and turntable cross frames, it is often impossible to avoid field riveting in close corners and places inaccessible except to the shortest special riveting tools such as jam riveting hammers and holders-on.

Although the personnel of a riveting gang varies with working conditions, each of these steps in the process of riveting demands the attention of one or more skilled workmen. The incidental work of placing and moving scaffolds, keeping materials at hand, inspecting and marking defective rivets and care of tools require prompt and careful attention. Rivets are inspected in new work to find and replace those which do not completely fill the rivet holes and those which are not driven tight. Rivet inspection should closely follow the driving in order to avoid recalling riveters, tools and equipment and rebuilding scaffolds. Individual skill, efficient teamwork, careful supervision and intelligent inspection are necessary to successful field riveting.

RIVETING HAMMER (Pneumatic). An air driven tool used to compress, clinch and form heads on rivets by means of repeated blows on the rivet point.

The hammer commonly used in field riveting in connection with the maintenance of railway bridges resembles a large pistol and is often called a riveting gun. It consists of a handle with a trigger and throttle valve, a barrel, a piston and control valve and a contact bit called a rivet set. Hammers driving rivets up to 1 in. in diameter are usually supplied for railway bridge maintenance. An average hammer of this capacity has a piston stroke of about 6 to 8 in., weighs about 25 to 30 lbs., is 18 to 25 in. long exclusive of the rivet set, strikes about 750 blows per minute and consumes 20 to 25 cu. ft. of free air per minute.

The air is supplied to the hammer through a flexible armored hose connected by a nipple inserted in the rear lower curve of the handle, which may be of open style like a pistol handle or closed like some saw handles. The trigger is a small steel lever which opens the throttle valve when depressed. It is usually placed on the back of the handle so that when the handle is grasped and held against the work the trigger is in line with the pressure of the wrist. Another style of hammer has the trigger placed on the inside curve of the handle to be gripped by the fingers instead of being pressed against the palm. The throttle valve is usually located in the hammer handle just above the air inlet and is controlled by a plunger under pressure of the trigger from above. Some hammers have the control valve or valve chamber in line with the main bore through which the piston moves. Other styles have the valve block at the side or over the main bore.

Riveting hammers generally are made in three main parts, the handle, the valve block and the barrel. These parts are united by various screws and fastenings. Some hammer barrels, valves and handles, however, are one-piece forgings designed to eliminate a number of fastenings. The piston used in the field riveting hammer described above is a 1 1-16 in. by 3 in. cylindrical pin of crucible steel.

Control valves are variously constructed, the tendency being toward a reduction of the number of parts; prevention of injury to the valve by the piston; elimination of grit and dust from the air by straining it before it enters the valve; reducing the number and so increasing the areas of the ports to eliminate the tendency to clog the valve; and minimizing wear among the parts.

The barrel terminates in a part or fixture called a retainer which is designed to prevent the piston and rivet set from being accidentally discharged from the barrel. Some barrels contract near the muzzle, the bore being smaller for the tool shank than for the piston. While other styles of barrel have outside retainers converging over the muzzle so as to engage grooves or shoulders at the base of the tool shank, thus preventing the release of the piston and rivet set.

Rivet sets are contact tools usually made of crucible steel. The shanks are of standard designs either round or hexagonal. A shoulder or shoulders divide the shank from the striking head. The head is variously formed to give the desired shape to the rivet head. The commonly used standard shapes are the button head (most used in bridge work), cone head, pan head, and flush head. Other contact tools frequently used in pneumatic hammers are punches, drift bolt drivers and chisels for chipping rust or inequalities from metal surfaces and for cutting off rivet heads. A special short type of pneumatic hammer known as a jam riveter is used for work in close corners.

Until compressed air power came into general use for small tools, field riveting was done with hand riveting hammers. Hand riveting is comparatively slow, the blows struck are not always accurate nor

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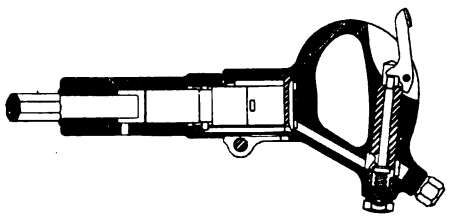
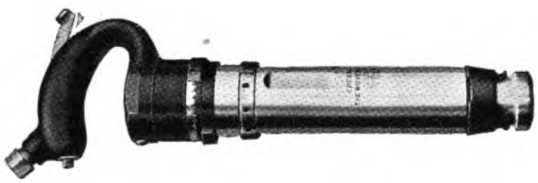
Cleveland Pocket-In-Head Riveting Hammer
The Cleveland Pneumatic Tool Co.



Little David Riveting Hammer
The Ingersoll-Rand Co.

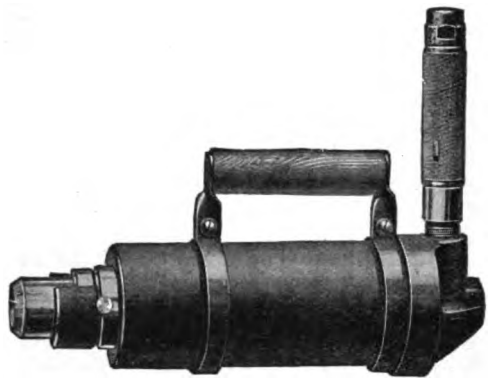
Thor Riveting Hammer
The Independent Pneumatic Tool Co.
(See Page 715)



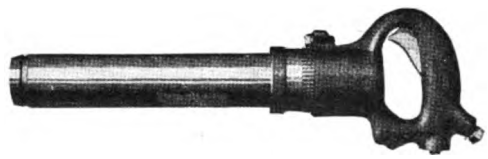
Boyer Pneumatic Riveting Hammer
The Chicago Pneumatic Tool Co.
(See Page 666)

The Keller Master Riveter
The Keller Pneumatic Tool Co.

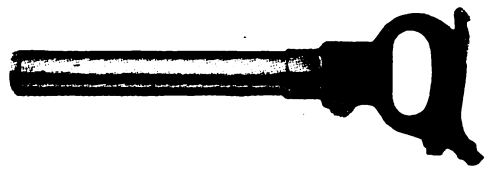
Little David Holder-On
The Ingersoll-Rand Co.



Boyer Holder-On
The Chicago Pneumatic Tool Co.
(See Page 666)



S. S. S. Riveter
The Standard Scale and Supply Co.



Helwig Riveter
The Helwig Manufacturing Co.

Duntley Riveting Hammer
The Duntley Co.

equally powerful, the rivet sometimes cools before the fit and head are perfected and there is a tendency to slight hand driving of rivets which are hard to reach. Portable air compressors and pneumatic tools at hand and ready for use are now generally recognized to be of distinct advantage to the bridge maintenance departments of railways. Although the extensive equipment and organizations of bridge fabricating and erecting concerns are necessary for the larger structural work on railways, there are many minor repairs and alterations which can be done

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economically by company forces with portable machine tools. The usual outfit is an engine for developing power, and air compressors, compressed air receivers and the necessary connecting pipe, hose and fittings, all mounted on and housed in one covered car.

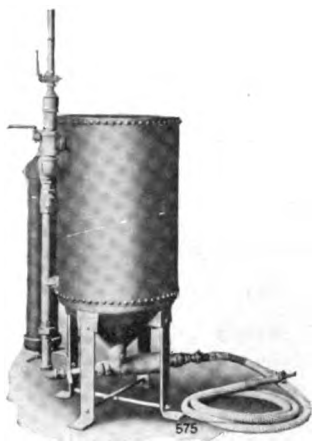
The use of pneumatic tools presupposes an ample supply of compressed air. It is well to provide machinery capable of compressing twice the air which the tools are calculated to consume. With an adequate set of air-driven tools and accessories, a riveting gang can accomplish several times the amount of work that is possible with the same number of men equipped with hand riveting hammers in a given period.

The pneumatic field riveting hammer is required to withstand severe usage. Possible adverse service conditions, especially frost, humidity, dust, sand, thickening oil and wear among the moving parts demand excellence in design, materials and manufacture of these tools. They must be light weight, strong, speedy, powerful, economical in use of air, delicate in throttle control, with a minimum of recoil and vibration, and safe to operate. In grip and finish the handle is designed to prevent slippage, and afford easy control. The accessibility of parts permits the careful and frequent cleaning and oiling which lengthens the service life of machine tools. See Riveting.

S

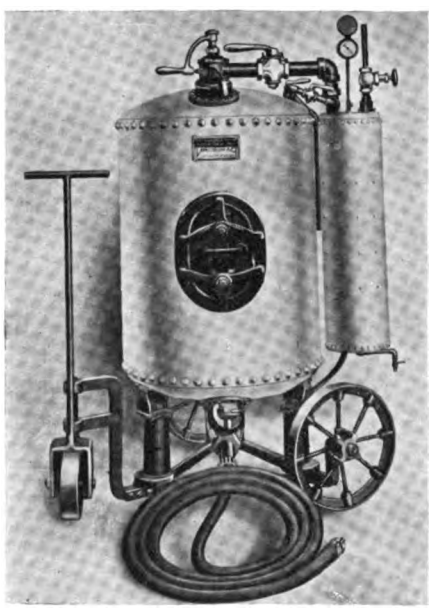
SAND BLAST. A stream of sand forcibly projected by means of compressed air or other power to remove old paint, rust, scale, etc., from metal surfaces to clean them, especially in preparation for painting.

The abrasive is discharged at high pressure from a nozzle, usually out of the sand chamber of the machine (where it is already under pressure) in combination with the compressed air. This method is known as the direct pressure system or hose system and is particularly adapted and in general use on extensive surfaces, such as bridge girders, although by this method anything can be handled which can be cleaned by any other type of machine. The suction system, in which the abrasive is carried to the nozzle by suction created by a jet of compressed air discharging through the nozzle and carrying the abrasive with it, is used for smaller work, usually in combination with an arrangement for reclaiming the used sand. In the gravity system the sand is brought to a point above the nozzle by gravity where it is combined with the compressed air and discharged. Although silica sand and sea sand are the cheapest and most used abrasives, they are more dusty than steel grit, shot and other metallic abrasives, and require frequent screening if reused from metallic abrasives. Dust, however, tends to settle on and adhere to the work, which is undesirable, especially in surfaces to be galvanized, etc.



The Doelcam Sand Blast Hose Machine
The Macleod Co.

The volume of air flow is governed by the area of the aperture in the nozzle and by the pressure which should be of an intensity suitable to the resistance of the metal to impact. Moisture must be removed from the compressed air to avoid dampening the abrasive and clogging the sand blast machine. As in all other work done by pneumatic power it is advisable to have an air compressor of ample power and speed. Dust arrestors are usually indispensable for shop sand blasting but are rarely used in field work. A hose sand blast machine consists essentially of a cylindrical steel sand and compressed air container, a smaller cylinder in which are mounted alternate plain and perforated plates to separate moisture and oil from the compressed air, a length of air hose with suitable nozzles, all fitted by means of valves, pipes, etc., to connect the machine with the compressor plant. Operators are furnished with protective masks and gauntlet gloves. If properly used and maintained the sand blast is effective and economical for cleaning metal bridge members, etc., to prepare them for painting, especially extensive plates such as girder webs. The area which can be cleaned in a given time depends on many factors, especially on the adherence of old paint, the extent of corrosion, etc., as well as on the manipulation of the blast. Care is required to avoid excessive abrasion and removal of metal. Abraded surfaces quickly oxidize and should therefore be painted at once after applying the sand blast. Heavy bridge scale is chipped off as the sand blast will not remove it without excessive abrasion around the scale.



Standard Pressure Hose Sand Blast Mounted on Hand Truck
The Pangborn Corporation

SHACKLE. A metal U-shaped link designed to be coupled to a ring or eyelet bolt by means of a removable bar or bolt passing through eyes at the

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extremities of each arm. Shackles are commonly used at the end of the fall line of a derrick to connect it with the arms of a hook for handling material. See I-Beam Hook.

SILL, BRIDGE. A lower horizontal member of a framed bent. (A. R. E. A.) The posts of a bent stand on and are secured to or framed into the sill. See Intermediate Sill. Also Trestle Bridge.

SKIN FRICTION. The friction between the surfaces of a pile, pier or caisson and the surrounding ground which tends to prevent the pile from moving vertically.

After a pile has been partly driven, frequently with the greatest ease and left to stand for a time, it usually drives hard for the first few blows of the second driving due to skin friction, but after being jarred loose it may again drive easily. See Pile.

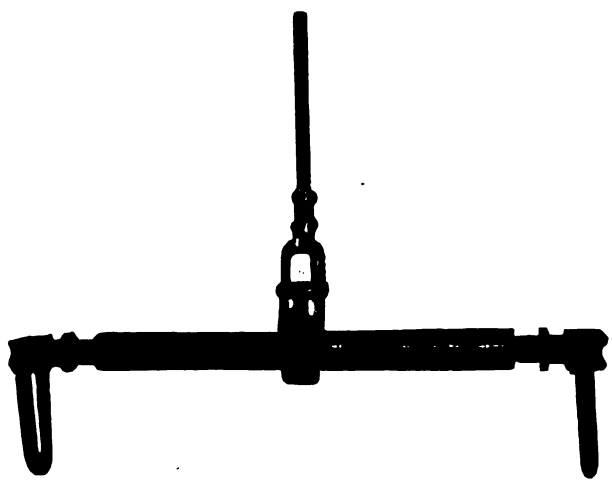
SNAP (Rivet). See Rivet Set.

SPACING STRIP (Bulk Head). A strip usually of wood about 1 in. by 3 in. in section, secured vertically between a bridge end and the timber bulkhead to separate the wood surface from the surface of the bulk head, with a view to minimizing decay. See Bulk Head.

SPANDREL. The space between the extrados line of an arch and the enclosing right angle; or between the extrados lines of adjacent arches and a horizontal line above them, or another arch above and enclosing them. See Arch.

STEAMBOAT RATCHET. A turnbuckle device used to draw the members of a structure together or to remove the tension from the parts while substitutions are being made.

This tool, sometimes called a pulling jack, commonly consists of a steel tube about 2½ ft. long with



Steamboat Ratchet

two oppositely threaded end portions designed to engage the threads of two steel rods, one of which screws into the tube at each end. A link and hook is fastened to the end of the shank of each rod. The rods are oppositely threaded to mesh with the threads of the tube, the overall length being varied by means of a central ratchet which turns the tube, while links and hooks on the working ends of the rods hold the members of a structure.

STRINGER. A longitudinal bridge member designed to span horizontally as a beam from bent to bent, or from floor beam to floor beam, to support the track.

Timber stringers are about twice as deep as their widths and long enough to extend over two spans, common dimensions being 8 in. by 16 in. by 28 ft., three or four stringers being combined to form a chord with one such chord centered under each running rail of the track. Stringers of steel bridges are usually in pairs spaced 6 ft. 6 in. center to center, connecting at their ends with the transverse floor beams. Four stringers are sometimes used under one track in which case each pair is spaced symmetrically beneath the rail. See Bridge.

STRINGER BOLT. A long bridge bolt used to hold the stringers of a wooden bridge together to form a chord.

STRINGER CHORD. One of two longitudinal members of a bridge, each of which is made up of two or more parallel lines of stringers placed end to end and extending from bent to bent to support the track. The stringers in adjacent lines break joints over alternate bents, the chord thus acting as a continuous girder. The lines of stringers are combined by means of transverse bolts which extend also through packing blocks placed between the stringers to separate their side surfaces with a view to minimizing decay and the fire hazard in timber structures. The stringer chords are placed symmetrically about the running rails, one chord beneath each rail, and held in line by means of blocks spiked on the caps or by some similar device to preserve the spacing. See Bridge. Also Stringer.

STRUT. A brace or spacing member of a bridge designed to resist compression in the direction of its length.

This term is used to denote the horizontal concrete cross members in the floor of an arch culvert between which the paving is placed, as well as various compression members in wood and steel structures.

SUBSTRUCTURE (Bridge). The abutments and piers and their supporting bases; such as reinforced concrete footings and the piles on which they are constructed. See Superstructure (Bridge).

SUPERSTRUCTURE (Bridge). That portion of a bridge which is supported on the piers and abutments, including the beams, girders or trusses, floor system and bracing. See Substructure (Bridge).

T

TELL TALE. See Bridge Warning.

THREE-HINGED ARCH. An arch having a hinge at the crown and another at each support; the hinge usually consisting of cast steel pins, or flat lead plates, or steel plates covered with lead. This

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Sketch of a Three Hinged Arch

type of structure is sometimes constructed where an unusually long span is necessary, or where the foundation is yielding, the design permitting of considerable unit movement without injury to the arch. See Arch.

TRANSFER TABLE. A traveling structure with a track on which a locomotive or car can be run and transferred from one parallel track to another. (A. R. E. A.)

A transfer table for handling cars and locomotives generally consists of a rigid structural steel frame carried on wheels running on two or more rails in a pit. The lengths of the table varies with the equipment to be moved and frequently is as much as 80 ft. in length, while the pit is seldom more than 2 ft. in depth and as long as the front of the shop or other building into which the cars or engines are transferred.

Transfer tables are usually operated by an electric motor controlled from a central cabin, the current being taken from either an overhead trolley line or from wire strung along the side walls of the pit. The parallel tracks served are straight and extend from the shop and from their origin to the edge of the transfer pit, and from the opposite edge of the pit into the shop, any track being completed by moving the transfer table into line or supply the section of track over the pit, to receive or discharge engines or cars to or from the shop.

TRESTLE. Broadly, a support for a structure; as a pile bent, or a builder's scaffolding. This term is commonly applied also to a railway bridge supported on trestles, usually a wooden structure of spans 10 to 16 ft. long. See Trestle Bridge. Also Bridge.

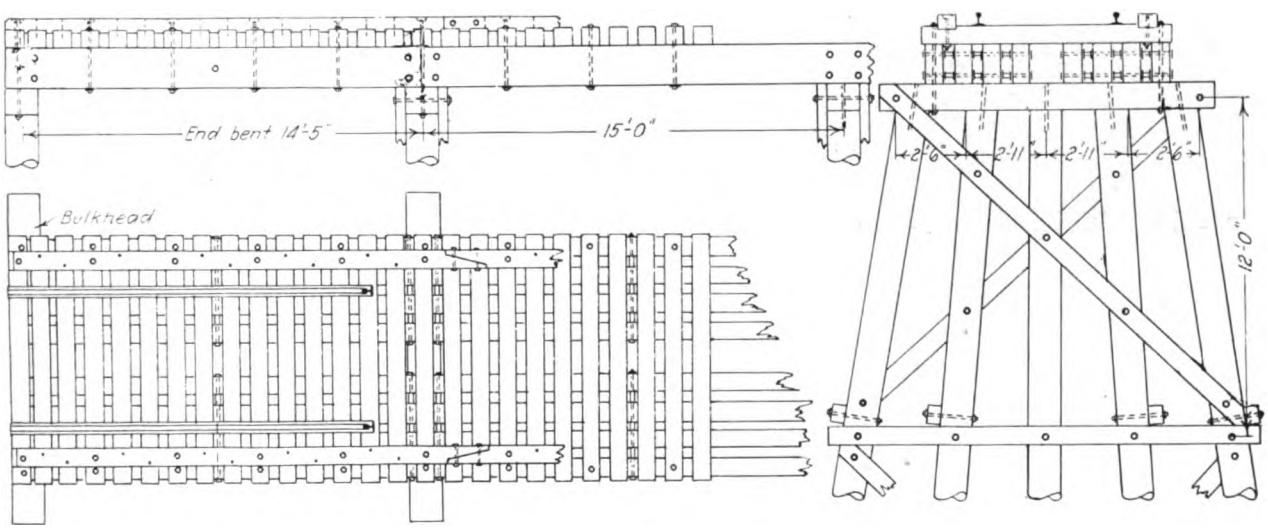
TRESTLE, BALLAST FLOOR. A trestle having a tight wooden floor on which the ballast and the track are supported with a view to obtaining an unbroken roadbed on which the track can be lined and surfaced at a minimum maintenance cost while prolonging the service life of the substructure, minimizing the fire hazard and providing greater safety in case of derailments. It is not easily drained nor can it be inspected readily.

There are two general types, one consisting essentially of separated stringers braced with bridging and covered with a tight plank floor for the ballast, while in the second type the stringers, laid closely together, form a solid floor that carries the ballast directly.

Wooden guard timbers well bolted on top of and parrallel to the outside stringers act as side boards to retain the ballast. Since the timbers of ballast floor trestles are subjected to dryness beneath and to moisture held in the ballast above, they are generally treated with wood preservative. See Trestle. Also Bridge Floor.

TRESTLE BRIDGE. A bridge composed of relatively short spans of simple horizontal members or beams, supported on caps resting on upright members placed transversely to the axis of the structure and forming bents or trestles used as loads applied to the horizontal members.

Trestle bridges are made of timber, steel or reinforced concrete or a combination of two or all of these materials. The entire structure however is frequently called a trestle, timber trestle bridges supported on pile bents or on framed bents of timber posts, caps and sills, being known as pile trestles or framed trestles. A timber pile bent consists usually of four or more wooden piles driven in a line at right angles to the center line of the bridge, sawed off level at the top to receive a cap, usually a 12 in. by 14 in. by 16 ft. squared timber set on edge and sized ½ in. over the piles to which it is held by means of drift bolts driven through the cap



Sketch of a Typical Pile Trestle

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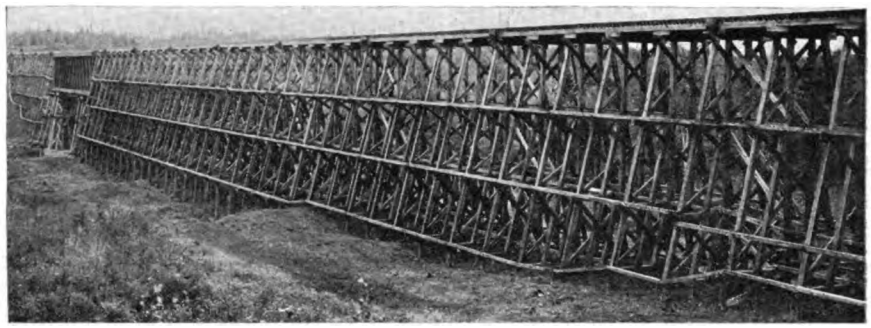
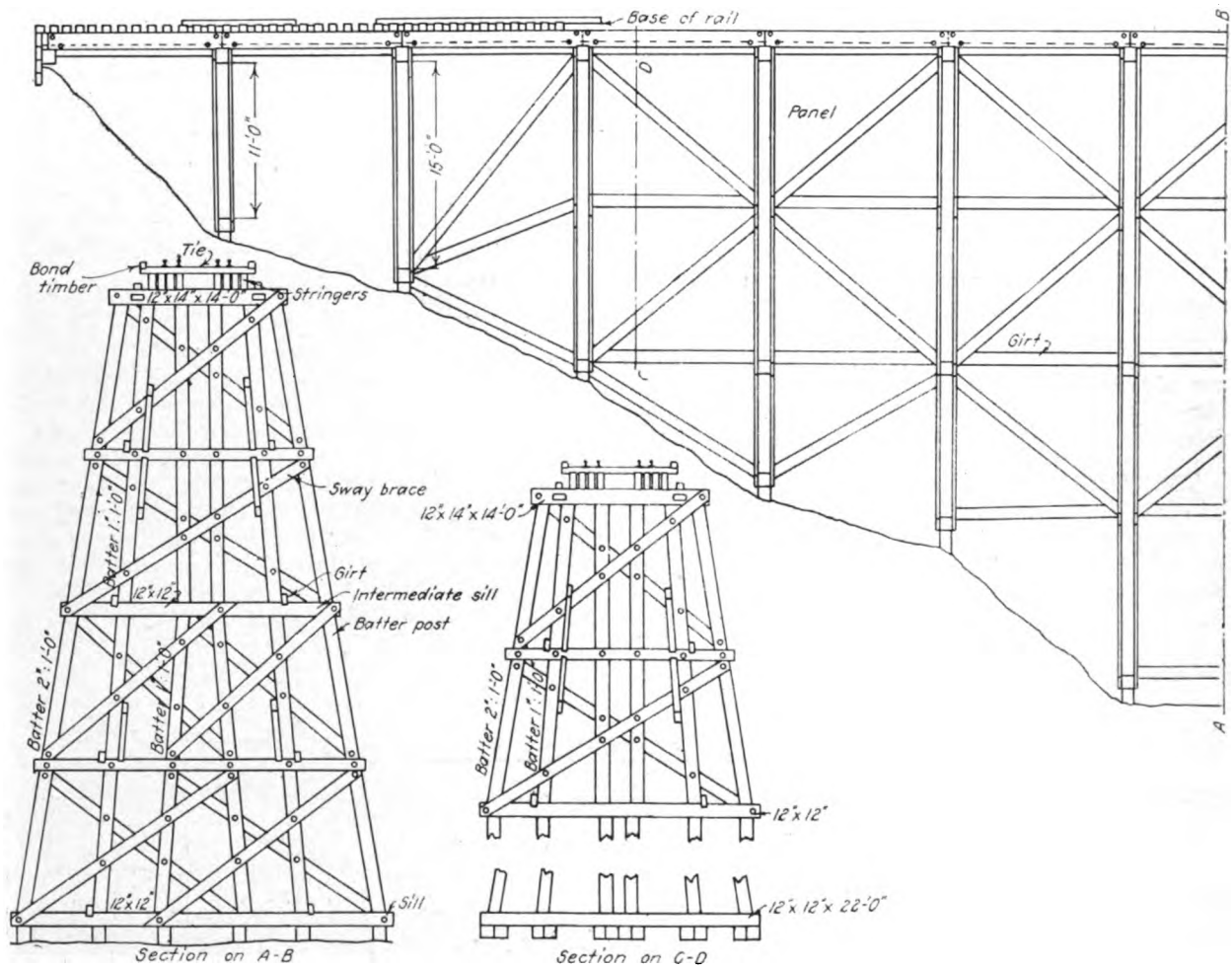
into the piles. The end bents of a bridge cut off in the earth of the embankment, commonly consist of four piles for a single track bent, while the intermediate bents have five or six piles. Wooden stringers, usually 8 in. by 16 in. timbers, long enough to reach horizontally in two parallel chords which are placed on the caps, or anchored beneath each running rail, the bolts passing through spacing blocks or packing spools placed between



A Long Frame Trestle Bridge



Sketch of a Wooden Frame Trestle

adjacent stringers of a chord as preventives of decay and a measure of safety against fire. The two or three lines of stringers of a chord are laid to break joints, the end of any stringer of an intermediate line being opposite the center of an adjacent stringer, this arrangement of the chord members forming a continuous girder. The spacing blocks are usually cast iron spools though wood blocks or cast iron washers are sometimes used. The stringer chord bolts pass through all the spools and stringers of a chord and hold them together between cast iron or wrought iron washers, one at the head or the bolt and one at the threaded nut end. A wooden spacer plank is sometimes spiked on the cap under the stringers as a bearing for the joint or a short piece of stringer about 6 ft. long called a corbel is

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inserted to increase the bearing. The track ties are laid directly on and across the stringers and are held down on them and spaced by longitudinal bond timbers, bolted or screwed to and sometimes dapped over the ties, and bolted at intervals to the stringers or caps.

In order to stabilize the structure the outermost pile on each side of the bent is battered from 1 in. to 3 in. per ft. of height, and a sway brace, usually of 3 in. by 10 in. or 12 in. planking, is bolted or spiked diagonally across the upright members from the end of the cap on one side of the track to the base of the batter pile on the other side, while another brace is oppositely placed on the other face of the bent. These sway braces are usually bolted together at the center where they cross. To retain the slopes at the ends of the trestles, wooden bulk heads of planking are spiked to the piling behind vertical wood spacing strips.

The designs of reinforced concrete trestles are similar to the timber trestle in their main features and are used where long lived structures of short spans and medium cost are desired instead of longer steel spans on permanent foundations, as in wide river bottoms and swamps. The members are usually pre-cast in sections of sizes and weights transported readily and erected economically, with a minimum of delay to traffic. When the height of the structure is 16 ft. or less, concrete piles and caps are commonly used while piers are substituted for higher trestles.

Concrete Pile Trestle

Some rather extensive trestles are provided with anchor piers at every tenth or twelfth span. The reinforced concrete piles are designed to be either driven or jetted into the ground, some having longitudinal holes through the core with connecting perforations in the sides for water jetting while the heads are encased in the underside of the cap which is cast in place around them. The floor of the bridge is preferably made of reinforced concrete slabs, though some are made of concrete-encased steel girders. Each span of a concrete slab floor bridge consists usually of two reinforced slabs, one on each side of the center line of track. The ballast and track are laid directly on these slabs which are provided with drain holes, with side parapets of concrete to retain the ballast and with U-bolts to permit of ready handling with the aid of derrick hooks.

The slabs may be coated with some waterproofing compound after each erection. Reinforced concrete trestles on piles or piers are in common use on a number of railways, several of which have adopted them as standard construction.

Steel trestle bridges are deck girder structures, usually on towered steel bents which rest on concrete footings. Commonly each of the four columns of the two bents forming a tower stands on a detached pyramidal footing of masonry. It is advisable to consider placing the masonry on wooden foundation piles unless the strata are of unquestioned bearing power, preferably rock, as the area of the base of the footing is usually limited. In order to save masonry the footings are placed without reference to their relative top levels and the lengths of the columns are varied to correspond. In such cases the lowest horizontal tower bracing is placed just above the level of the base of the shortest of the four columns, or the bottom member connecting bases at different elevations may be inclined. When the columns are latticed, the lattice bracing is placed on the open sides nearest the center line of the bridge. Diagonal bracing occupies the rectangular spaces between the tower columns and the horizontal braces if any which connect them. The columns of a bent are connected at their upper ends by a transverse member serving the purpose of a strut in single track bents and of a cross girder to carry the track girders in double track bents. The deck girder is secured by its bottom flanges to the bearing plates on the columns by means of holding-down bolts which pass through expansion slots. The abutments of steel trestles are usually of masonry. As a temporary measure, the abutments are sometimes of wooden construction, to effect economy in first cost, with a view to cutting off the piling and using it for the foundation of a permanent masonry structure when the embankment has settled. See Bridge. Also Trestle. Also Viaduct.

TRUSS. A framework composed of members placed at various angles in the same plane and so arranged that they can resist forces applied at any point where the members meet while subjecting the members only to compressive or tensile stresses. Trusses for railroad bridges are usually placed vertically in pairs with the train load supported between them with the aid of a floor system.

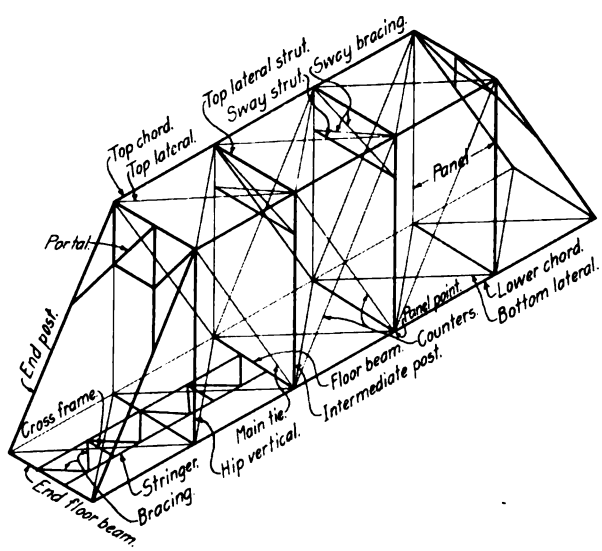

Diagram of a Through Truss Bridge

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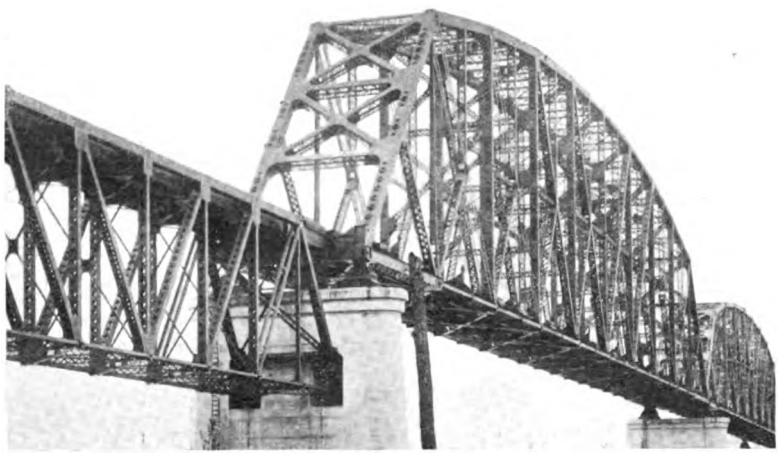
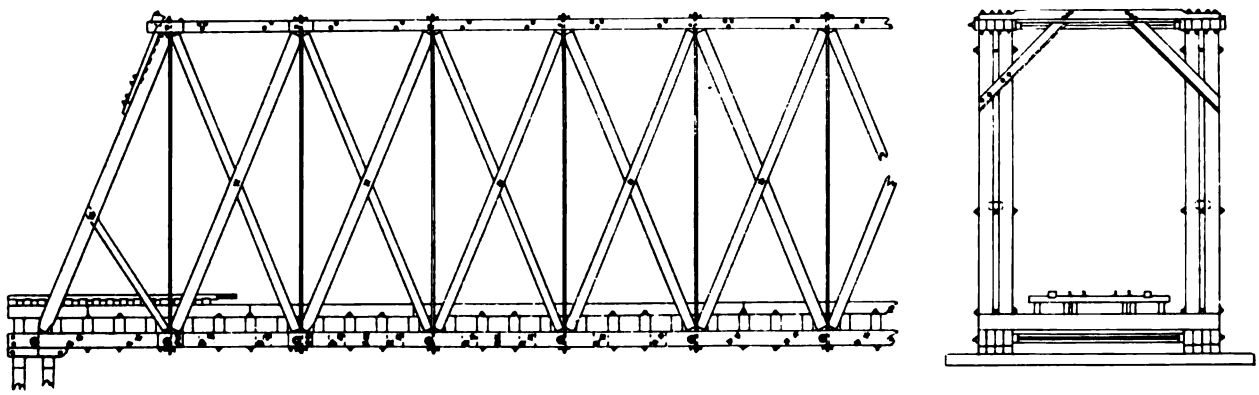
Warren Riveted Deck Truss Bridge



Pin Connected Pettit Through Trusses and a Pratt Deck Truss Span

Through Riveted Pratt Truss

Deck Howe Truss



Details of a Through Howe Truss Span

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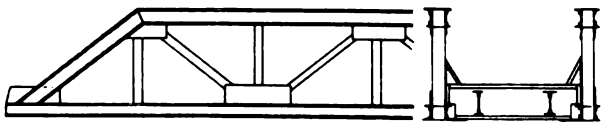
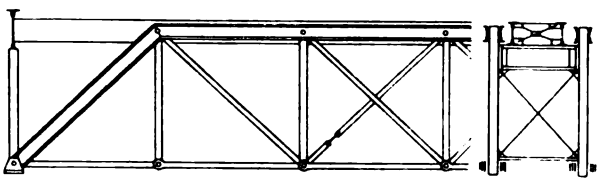
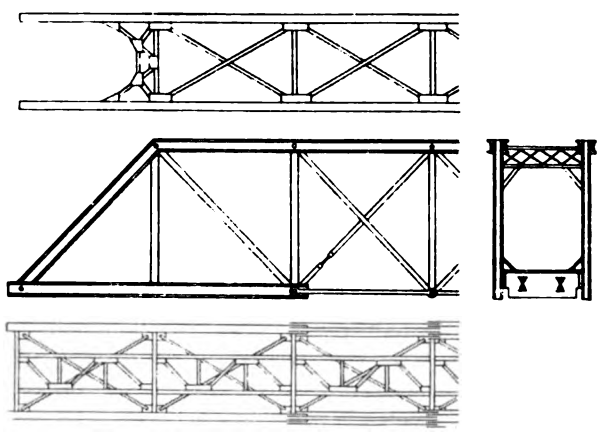
Riveted Pettit Through Truss



Sketch of a Through Riveted Pony Truss



Sketch of a Pin Connected Deck Truss



Sketch of a Pin Connected Pratt Truss

TRUSS, PIN CONNECTED. A truss composed of members which are connected by means of pins placed through bored holes provided for the purpose. See Eye Bar. Also Bridge.

TRUSS, RIVETED. A truss composed of members with connections secured by means of rivets. See Bridge.

TURNBUCKLE. A device for connecting, shortening, and tightening stay rods or other tension members. A turnbuckle is essentially a threaded

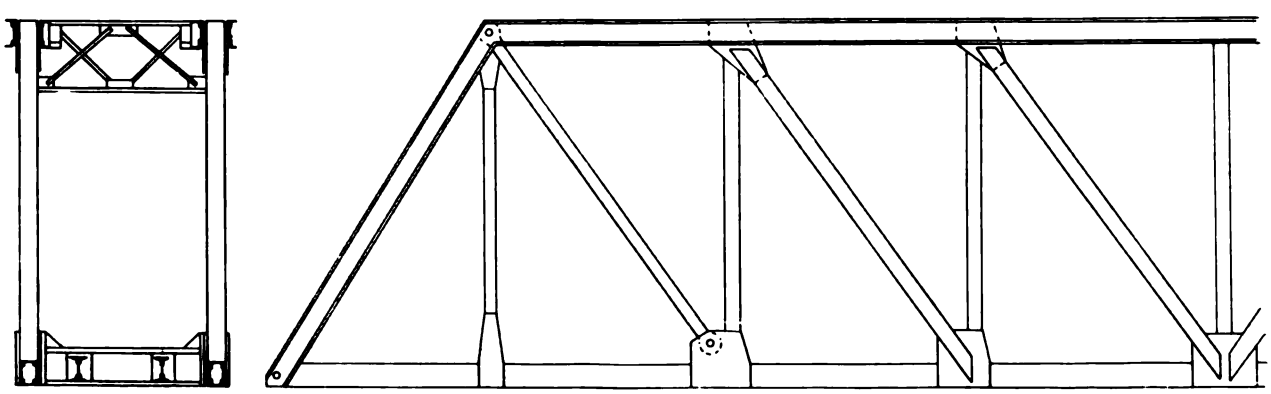
Turnbuckle

loop, link or eye of metal with a nut at either end, one having a left hand screwed thread while the other end has a right handed thread. See Steamboat Ratchet.

TURNTABLE. A revolving structure for turning locomotives and cars. (A. R. E. A.)

A turntable is essentially a single track swing span revolving on a central pivotal bearing surrounded by a roller or disc turning device, and on two end trucks, each having two flangeless tandem wheels or one wheel moving on a circumferential mono-rail track in a circular bowl-shaped pit enclosed by means of a vertical masonry wall, the level coping supporting the rail ends of radial yard tracks with any of which the turntable track will connect when the rails are brought into line.

The turntable girders are deepest at the central section, tapering thence to the comparatively shallow ends. While deck plate girders are in more general use, the through girder table is favored in special locations as where a long table of heavy capacity is needed in a shallow pit, an advantageous arrangement where good drainage is unobtainable from a deeper pit. A through girder turntable is more than twice the width of a deck girder table from center to center of girders, the latter being usually about 8 ft. wide. The through table has floor beams, stringers, and lateral diagonals arranged in a floor system comparable with bridge floors, while the deck girder type has the usual cross frames and diagonal



Sketch of a Through Riveted Pratt Truss

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laterals of deck spans, the ties resting on the top flanges.

These steel types superseded the wooden truss turntables with the lengthening of locomotives and the increase in axle loading. The turntable is made long enough to balance a locomotive with an empty tender while turning. The lengths of tables range from about 60 ft. to 110 ft., their capacities varying from 150 tons to 350 tons or more. The table should be long enough to balance the longest locomotive with its empty tender as the balance assists the turning movement and loads the structure symmetrically. The selection of a turntable depends on the capacity required, on the lengths and centers of gravity of the locomotives with empty tenders and on the available depth of pit floor above drainage.

To replace a turntable serving a radial engine house the new turntable must be centered in the exact location of the old one to maintain its relation as the point of origin of the radial tracks. Frequently the replacement involves an increase in the length of the table and the depth of the girder, necessitating the complete rebuilding of the pit as well as the equal shortening of all the tracks served.

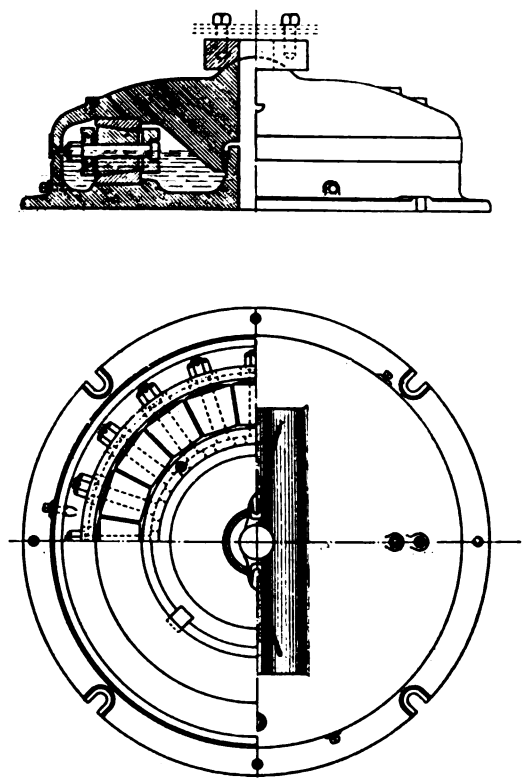
The center is placed on a carefully prepared foundation, usually of concrete with more or less reinforcing, over an area occupied by wooden piles driven at distances of 2 ft. or more to center, provided the stratum at foundation level requires such reinforcement to bear the frequent concentrated loads. The turntable center is a steel rotating device of one of two general classes, the roller design and the disc design. In the roller type of center the two principal parts are a lower circular flanged base and an upper convex top, which revolves on the fixed base by means of radial roller bearings, usually conical, made of special alloy steel and bolted between circular rims within the lower roller box. A pair of longitudinal girders between the main girders bear on a saddle block which rests on a central ridge on the upper roller box, the rollers moving in a chamber half filled with oil.

The disc type consists essentially of a bottom fixed disc of special steel which is surmounted by a saddle casting to which loads are transferred by means of loading brackets, the whole being enclosed between the main girders of the turntable and cross girders. The discs may have a flat or slightly convex contact surface, which is kept well lubricated.

Turntables designed to turn light engines are usually turned by hand, a lever attached to the side of the deck at each end extending beyond the limits of the span so that several men can move the table by pushing to the right or left against both levers simultaneously if necessary. Although a common method is to fix wooden hand levers in vertically inclined planes, a more convenient arrangement consists of a horizontal iron pipe lever sliding through circular collars on two upright steel posts bolted to the ties on the deck about 10 ft. apart. When the lever is not in use it is pushed toward the center until a knob at the outer end bears against the collar of the end post when it is out of the way of employees passing the table.

Heavy duty tables at important engine terminals are preferably power-operated, the usual method where power is readily available being a tractor situated near the end of the girder in the pit over the circle rail at the side of and attached to the table. Electric operating power may be overhead or underground, the latter requiring a careful and comparatively expensive installation involving efficient drainage of the pit, but permitting the grounding of exposed wires not carrying current as well as affording protection from fire, while the overhead installation possesses the advantage of accessibility. Compressed air tractors and gas engines are also sometimes used.

As the bow-shaped bottom flanges of deck turntable girders usually clear the floor of the pit only a few inches, it is necessary to provide one or more recesses in the circle wall from which access may be obtained to the area between the girders for purposes of inspection and repair. The center, which requires the closest attention and most careful maintenance, is preferably provided with an oil pipe extending up between the ties to the deck, affording a convenient means of lubrication. The deck usually carries a footway with an outside handrail on each side of the track, a suitable number of long ties or interwoven standard length ties being installed to carry them.



Standard Turntable Center
The American Bridge Co.

Rail locks are usually provided at the ends of the turntable track to keep them in alignment with the rails of the approach track while rolling stock is being transferred and to protect the ends of the rails at the temporary joint. There is always a certain amount of vertical play at the end of the table when a locomotive passes and there is a corresponding

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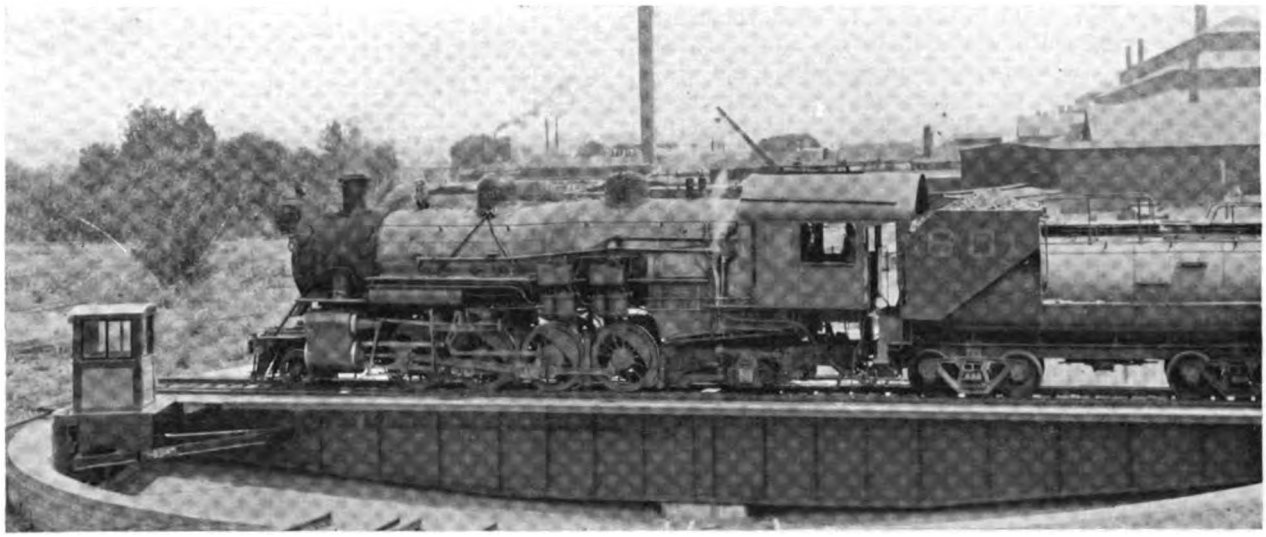


Turntable with Tractor
George P. Nichols & Bro.
(See Page 757)

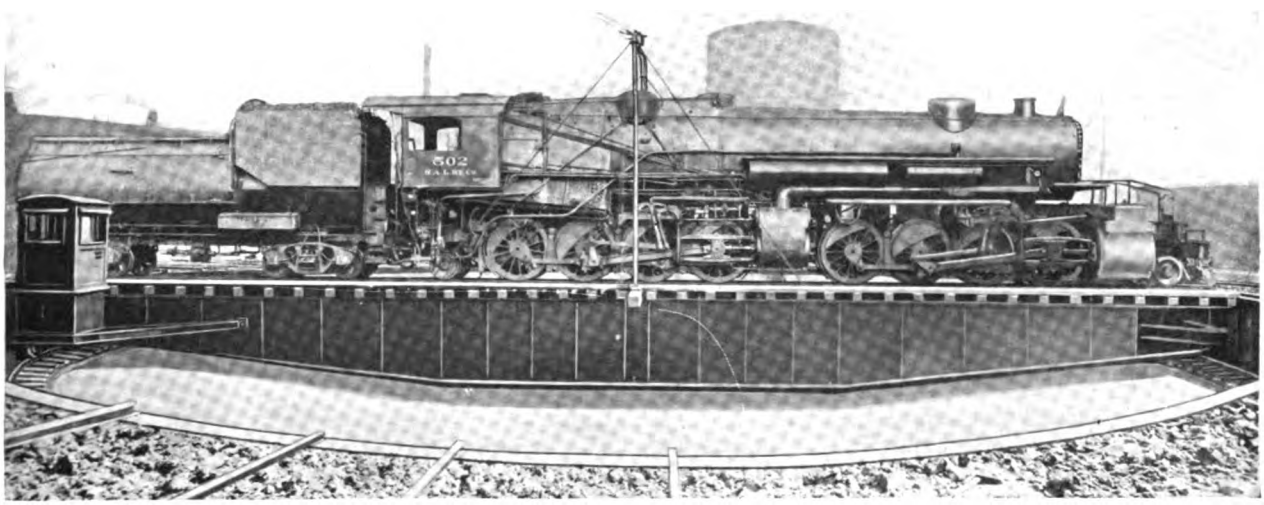
tendency to batter the heads of the adjacent rail ends, which cannot readily be brought closer than ½ in. apart. These rail locks, which may be either hand or power-operated, do not differ materially from those used on draw bridges. See Rail Lock. Also Turntable Pit.

TURNTABLE CENTER. An assembly of castings, etc., which constitute the pivoted device on which a locomotive turntable and its loads are revolved. The lower base casting is fixed while the top casting is attached to the turntable and revolves with it on the base. See Turntable.

TURNTABLE PIT. A circular pit depressed below the surface of the ground in which the turntable revolves on a turning device called a center.

The walls and floor of the pit are usually made of masonry and preferably of concrete. The foundation of the center is normally made with a view to permanence, consisting usually of reinforced or mass concrete spread sufficiently to obtain the desired bearing area or placed on a sub-foundation of piles driven on 2 ft. to 3 ft. centers in an area of about 150 sq. ft. or more according to the bearing force of the soil. The concrete base built on this prepared foundation may be of any dimensions, depending on the loadings and the reinforcement employed. The bearing block for the center casting is preferably reinforced and is provided with holding-down bolts to secure the base casting.

The circle wall is placed on suitable footings while an inside circular concrete step with a level top surface is provided to carry the circle rail, sometimes on ties and sometimes on chairs secured directly to the concrete. The exposed face of the wall above the circle rail is vertical, equi-distant at all points from the center, and provided with a level coping which sometimes has holding-down bolts for chairs or tie plates of the radial yard track rails. Two recesses are preferably provided at opposite points



Turntable with Tractor
The R. W. Young Manufacturing Co.
(See Page 843)

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in the inner face of the circle wall to make room for employees engaged in maintaining the table. These recesses have entrance steps, and are walled and usually floored. While many turntable pits in favorable soil are not floored, it is considered good practise to install concrete floors with ample outlet drains to carry all moisture away from the foundations and from the electric wire conduits, if any. Pits are sometimes covered in winter to prevent snow from obstructing them. One style of covering is a wood platform which is circular, being built on timbers extended from the turntable deck and braced from the bottom flanges. To further protect the table from moisture and ice a stove is sometimes placed partly beneath the platform close to the girder at one side of the center. Exhaust steam from the engine house is sometimes led in pipes around the circle rail and center casting to melt the snow, or the drainage outlet is raised by means of a flanged collar so that a certain depth of water will be retained in the pit. Exhaust steam is used to keep this water hot while the snow from the vicinity, shoveled into the pit, is melted and carried out through the drain, the overflow level being below the center casting. In extremely cold climates turntable pits are sometimes built inside the engine house to protect the facilities entirely from the weather. Turntable walls are sometimes made of stone, brick or other masonry or of timber and sometimes the perpendicular wall is not carried all around the circle, but is limited to opposite arcs which include the track ends, the circle rail and its foundation however being continuous. The use of concrete or brick for turntable pits with provisions for rail bearings on the copings is recommended by the A. R. E. A.

TURNTABLE TRACTOR. A tractor designed to rotate with and control the movement of a locomotive turntable, by the application of power in a line with the circle rail.

The tractor consists essentially of a power unit mounted in a frame which is supported on a flangeless wheel or wheels moving on the circle rail, and surmounted by a platform which serves as the floor of the operators cab. The machine is attached to the swing span of the turntable by means of structural beams extending from the front and rear members of the frame to the adjacent main girder of the table. The cab contains the operating device, power control, sand levers and brakes, the engine or motor, gear wheels, etc., being located beneath the floor. While any convenient power may be employed, such as gasoline, compressed air or electricity, the last is in most general use for heavy capacity tables at important terminals where many movements of large locomotives are required. The electric power may be brought to the tractor by an overhead system of wires or through underground ducts, the electric collector being adapted to installation overhead on a frame at the center of the table which provides clearance for locomotives. The frame of the tractor is usually of riveted steel shapes while the cab is of wood or steel construction, and a rail sanding device is included in the equipment. The two connections with the turntable are widely separated while the wheel or wheels supply the main support of the machine. The tractor is operated by one man, all controls being within easy reach.

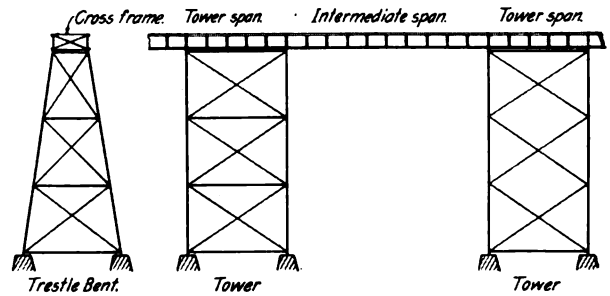
U

UPSET (Rivet). A rivet, the shank of which has been heated and then hammered end-wise with a riveting hammer to form a head, the diameter of which is greater than that of the shank. See Riveting.

UPSET (Rod). A round or square rod with threaded ends that have been enlarged by forging so that the net section at the root of the threads shall not be less than the sectional area of the body of the rod.

V

VIADUCT. A bridge consisting of a series of masonry arches or steel spans, usually an extensive structure erected to conduct a railway over a valley or depression or over existing channels of communi-



Viaduct Diagram

cation where an embankment would be inexpedient.

This term is sometimes applied in the broader sense to any long bridge supporting an elevated roadway, especially to steel bridges of a number of

Example of a High Viaduct

deck or truss spans or both, erected on tower-braced bents; or to a multiple arch bridge where the low spaces between the crowns of the several successive main arches are occupied by lesser arches of suitable heights and shorter spans designed to bring the entire masonry structure to the road bed level

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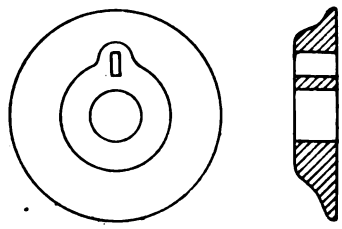
without the employment of loose material in embankment, which might necessitate extensive spandrel walls to retain its slopes. The masonry viaduct, as an elaboration of the simple arch, was extensively employed by the Romans in highway building, and the design survives in the many multiple arch structures of the Italian government railways crossing the Appenines between Rome and Venice, and in other European railway bridges. The steel viaduct, sometimes called trestle, is more commonly used in America. The small percentage of field work and the possibility of standardizing the shapes, thereby reducing details, has popularized this design, especially on railway systems having many extensive structures where economy and permanence on a large scale are attainable. The viaduct construction is frequently used on approach structures to long truss or other special spans over streams, etc. See Bridge.

WASHER. A circular disc usually of cast or malleable iron or plate steel with a hole in the center for a bolt to pass through. Washers are used to increase the bearing area of a bolt head or nut on the member through which the bolt passes. This is important in timber framing on account of the low compression value of timber across grain.

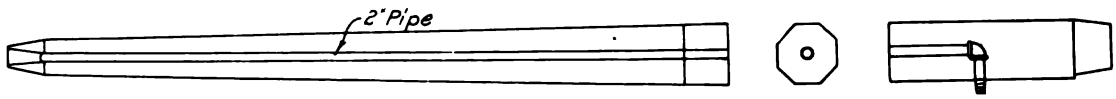


Slotted Bridge Washer

Malleable Iron Washers
The St. Louis Malleable Castings Co.

WATER JET. A stream of water forcibly impelled through a pipe or other tube and applied to the ground about the base of a pile as it is driven to facilitate the penetration by lessening the friction.

It is considered good practise to play the jet into the ground around the pipe rather than at a point at the tip, as the side play is best suited to lessening skin friction. The water jet method is especially valuable for driving in quick sand or any stratum of fine particles, which tend to crowd closely about the surface of the pile after each blow. See Pile Driver.



Concrete Pile Equipped with Pipe for Water Jet
Chicago, Milwaukee & St. Paul

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The
Building Section

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A

ABUTMENT, BUILDING. A masonry wall, pier or column from which an arch springs and is supported.

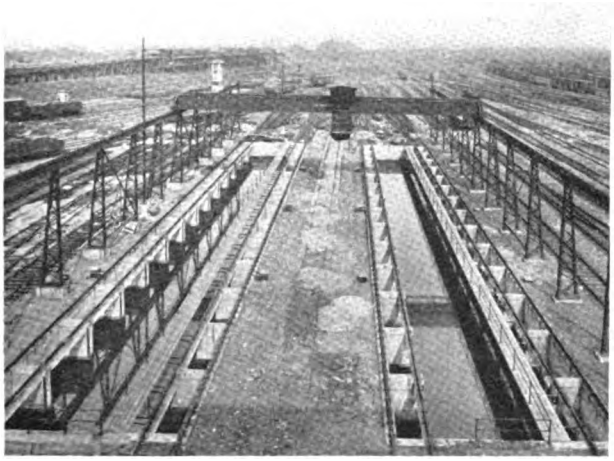
Building abutments are employed frequently in forming inside doorways in basements, as well as in the principal doorways and windows of the first and upper floors of extensive brick and other masonry structures such as passenger stations.

APRON (Window). The piece of wainscoting placed directly below the sash frame of a window, on the inside surface of the wall, sometimes called a pavel back. The window apron is a finishing piece designed to hide the rough top edge of the wall beneath the frame, as well as to form a base for the inner edge of the sill.

ARCH, BUILDING. A mechanical arrangement of masonry in the form of a curve, which preserves a given shape when resisting pressure and enables the masonry to carry weights when supported at the springing lines on piers or abutments. Masonry arches are employed frequently at the main entrances of extensive buildings such as passenger stations, as well as in large windows, and for inside doorways in basements, etc.

ARRIS. The figure formed by two surfaces meeting at an angle, as the equally convex surfaces which form the tops of some arched windows, the arcs intersecting to form an apex. See Arch, Building.

ASH PIT. A structure into which cinders from locomotives are deposited for subsequent removal. (A. R. E. A.)

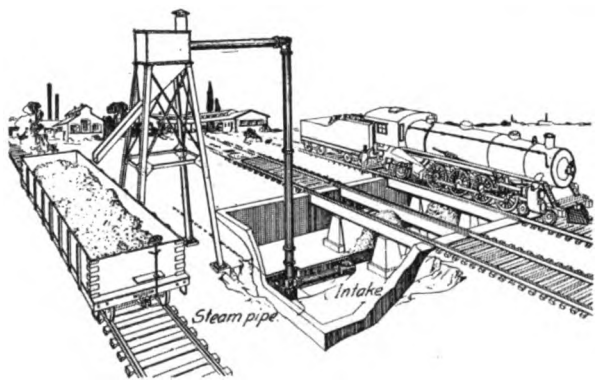


Submerged Ash Pit

An ash pit is constructed by excavating beneath the level of the track or tracks and constructing an open-top masonry enclosure with walls and a drainable masonry floor, on which lines of pedestals are placed to support the longitudinal girders that carry the track rails over the pit. Sometimes one rail of a track is carried on the side wall of the pit while its mate is carried on a girder and pedestals. At extensive stations, parallel tracks are carried over the ash pit which, though commonly only long enough for one locomotive, may be of any length. Ashes in pits are sometimes submerged in water and handled mechanically for removal, usually with grab buckets. This method preserves the structure and eliminates unpleasant labor and danger of accidents from hot ashes.

The walls and floors of ash pits are usually made of concrete and while due consideration is given to the severe service conditions of any container in which burning coals and cinders are deposited in large volume and wet down with water before removal, no better material seems available at reasonable cost, and no adequate protection is afforded the walls, which sometimes deteriorate gradually from the heat and water combined. The pedestals are preferably of non-corrosive, heat-resistant iron.

The removal of ashes is accomplished in several ways. Shoveling them by hand into cars is uneconomical, even where the material is not to be lifted. Various other methods of disposal are in use, such as an elevated, inclined narrow-gage track placed at



A Steam Conveyor Ash Pit

right angles to the pit tracks with an extension into the pit from which a steel tram car receives the ashes as they are dumped from the locomotive fire box, is then pulled to the top of the incline by means of a hoisting engine with a cable and dumps its contents over the top of the incline into a car placed for loading; or a steam jet is employed to blow the ashes through a large iron pipe line into an elevated hopper from which they are discharged by gravity through a spout into a waiting car. Sometimes dump buckets with bales are made to fit into the pit to receive the ashes from the locomotives. These containers, when filled with ashes are handled for disposal by means of a compressed air or electric crane which dumps the contents into cars; or overhead cranes or travelers are employed to handle the bucket. Frequently a depressed track is installed alongside of the pit on which cars are loaded with ashes for disposal, the depressed track floor being as low or lower than the floor of the pit, which is not walled on that side. As a measure of safety to employees handling the locomotives over the pit, walkways with handrails alongside the running tracks have been suggested by the committee on building of the A. R. E. A. These footways are designed to fill the entire open space between the track rail and the hand rail and are preferably designed to rest on steel stringers or I-beams.

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ASPHALT. A bitumen found naturally in a solid state. Asphalts are usually fluxed with petroleum products, the mixture of several ingredients of each class forming a combination much used in the making of ready roofing sheets and shingles. See Roofing.

B

BACKING (Rafter or Rib). The addition of materials to form an upper or outer surface so that it may range with the edges of the rafters or ribs on either side. Backing in the framing of buildings is composed of filling pieces used primarily to provide a bearing for other construction members.

BACK PLASTERING. The introduction of a lath and plaster wall on furring strips between the studdings of a frame building, thus dividing the thickness of the wall into two parts, affording a double air space with a view of providing insulation. Back plastering is usually limited to the outside walls and the upper ceiling of a building with a view to protecting the interior from heat and cold.

BALCONY. A platform projecting from the wall of a building within or without, supported by columns, pillars or consoles and encompassed by a balustrade or railing. Inside balconies are common only in lofty rooms such as the concourses, etc., of terminal passenger stations.

BALUSTER. A small column supporting a handrail which guards the side of a staircase.

Balusters are usually turned sticks about 3 in. square and 2 ft. 6 in. long but sometimes metal rods or pipes. One or two are usually placed on each step. They are preferably gained into the handrail at the top and into the buttress or close string at the bottom. They serve the three fold purpose of supporting the handrail, acting as pickets in a protecting barrier and giving a finished appearance to the stairway.

BALUSTRADE. A series of balusters connected by a handrail, serving as a protection along the edges of an elevated platform, as a safety barrier at the open side or sides of a stairway, etc. A balustrade is essentially a safety device and is frequently used whenever there is a footway at an elevation as about the front of a balcony or an elevated landing. See Baluster.

BASE (Column). That part of the support of a column introduced between the bottom of the shaft and the pedestal or plinth. The base of a column is the slab or thick flat layer of material, usually masonry, on which the shaft of the column bears directly. It is designed to distribute the load by means of its greater area and proportional thickness.

BASE BOARD. See Skirting.

BASEMENT. The lower part of a building which is situated at or slightly below the grade of the lot or street as distinguished from the cellar, which is within the foundations. A basement is used in some instances as the first floor of a building as when the foundation is in solid rock where excavation would be economically inadvisable.

BATTEN. A small scantling or strip of wood commonly nailed across boards to hold them in place or over the joints of sheathing to keep out the weather. The ordinary batten is $\frac{15}{16}$ in. by $1\frac{5}{8}$ in. to $2\frac{5}{8}$ in. random length. It is used as an outside covering for the crack between two upright boards of a wall, shed or other temporary building. A batten usually is shingle nailed to the boards it unites.

BAY. Any division, panel or compartment, as of a roof, a wall or a building as marked off by pillars, etc., as the walls of the stalls of a round house, each chord of the arc representing the line of one bay.

BAY WINDOW. Any window projecting outward from the wall of a building either square, polygonal or curved and supported on the foundation.

The telegrapher's lookout window in the office of a passenger station is preferably a square or rectangular bay, as this form provides the best view of the tracks.

BEAD. A small convex molding, in section a circular segment of 180 deg. or more. The bead is often ornamental, being commonly used to mark a junction or a separation between surfaces or to dress an angle, etc.

BEAM, COLLAR. A beam extending between and secured to two opposite rafters above their lower ends as a brace to prevent sagging or spreading. It also serves as a strut, a tie or a ceiling joist for a garret story.

BEARING BLOCK (Scale). A block of special alloy steel of suitable dimensions to form a bearing for a scale pivot.

A bearing block should be as hard or a little harder than the knife edge of the pivot bar, to prevent cutting. The bearing surface is ground to afford a continuity of contact throughout the length of the knife edge. See Scale.

BEARING WALL. A wall on which the floor and roof beams of a structure rest. While these are outside walls in small buildings they are sometimes built as inside division walls in more extensive structures.

BELT. A course of stone or brick projecting from a wall, usually placed in a line with the sills of the window of a building. A belt is used as a finishing course to relieve the plain appearance of a vertical wall, giving the effect of less height.

BOND TIMBER. A longitudinal timber placed in the wall of a building to tie the brickwork together and to which battens, laths, finish around door openings, etc., are secured.

Bond timbers, sometimes called bucks, are used commonly in tile and brick veneered walls. Some round houses have walls of brick 4 in. thick laid between 2-in. by 4-in. bond timbers, with wooden drop siding as an outside finish.

BRACE. An inclined piece of timber used in trusses partitions or in framed roofs in order to form a stiffener for the framing. Braces in partitions and span roofs are commonly disposed in pairs and are usually introduced in opposite directions. When used as supports for rafters they are generally called struts.

BRACKET. A piece or a combination of pieces of wood, stone or metal, generally triangular in

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shape, projecting from or fastened to a wall or other surface as a support for the eaves of a roof, or to strengthen an angle.

BREAK, BUILDING. Any projection from the general continuity of the surface of a building, such as an offset in a wall.

A chimney is sometimes built outside a wall, usually to afford more room or some other accommodation inside but frequently also for the purpose of forming a break in the outside surface of the wall; or a course of material is set to project for the same purpose. See Belt.

BREAKING JOINT. The arrangement of stones or brick to prevent two or more joints of successive courses from coming in line with each other, a solid part intervening above and below each joint.

BRIDGING (Building). Struts nailed between the adjacent sides of flooring joists or partition studding to brace and stiffen them.

Bridging may be herring bone (diagonally crossed) or solid.

Each set of herring bone bridging consists of two separate strips of wood, which are oppositely toe nailed between the adjacent surfaces of two parallel joists, thus cross-connecting and bracing them. It is common practice to brace a series of parallel joists with lines of bridging at regular intervals. The ordinary wooden herring bone bridging consists of 1-in. by 2-in. strips of wood with mitered ends. Solid bridging consists of sections of boards of the same depth as the joists, spanning the spaces between adjacent timbers over girders or sills.

BUILDING. A structure composed of materials put together to form a shelter of more or less permanency for persons or goods or both; sometimes a housing for carrying on business, such as the transportation of passengers and freight, with structures for subsidiary and allied purposes.

The common railway buildings are passenger stations, freight houses, ice houses, engine houses, shops, coaling stations, pump houses, dwellings including section houses, agents' houses and rest houses, boarding camps, section tool houses, oil houses, scale houses, watchmen's houses, telephone booths, etc. The buildings used for these purposes are of wide variety in extent, architecture, materials and workmanship. A large percentage are small frame buildings on temporary foundations. While a few are ornate and pretentious, most of them are plain and built with the evident desire to house the employees economically and carry on the business of the company.

Buildings are usually constructed on prepared foundations or on pillars, and of a great number of units some of which are formed and finished during the erection of the structure. Even extensive permanent buildings are sometimes moved, while other types known as portable buildings are made of a few large completed parts, which may be united quickly, erected and taken apart preparatory to moving and reassembly at any place.

The making of a building involves (1) materials, (2) labor, (3) transportation and (4) supervision. The various steps employed in building construction are (a) consideration of the necessity, the approximate investment and return, (b) selection of the location, (c) the preparation of plans, estimates and bills of material, (d) the purchase of materials and (e) the erection of the structure; the last two steps being to some extent coincident in many cases, the purchases being kept far enough in advance of use to permit time for delivery to avoid delay in erection.

The preparation of plans and specifications include proposals as to the kind and quantity of materials for the structure, the manner of handling and placing them, the sequence in which the work is to be done, etc. These stipulations include consideration of drainage, sewage and sanitation, insulation and artificial heating, natural and artificial lighting, the effects of the elements on materials and means for their protection, etc.

The materials selected depend on utility, availability, cost and transportation; climate, environment, and local conditions also influencing the selection. The construction of the building necessitates the use of certain plant and tools. Time is the essence of any such undertaking, depending largely on the supervision given to the purchase, delivery and use of all articles entering into the structure. See House.

BUTT JOINT. A joint formed by the squared ends of two pieces of timber which meet exactly endwise. Butt joints are extensively used in wooden frame buildings, as in the laying of hard wood flooring, where lengths have to be sawed to fit, etc.

BUTTRESS. A structure built against a wall for the purpose of giving it stability by bracing it against the thrust of a roof, also a name sometimes applied to any prop or support.

C

CASEMENT. A window, frame or sash, opening on hinges and revolving upon one of the vertical edges.

Casement windows may open out or in. They are made singly, doubly or in vertically hinged sections. When they open outward it is usual to arrange for inside rather than outside screens and storm sash. Those which open outward are more weather tight than the inward swinging type, although the fastenings and hangings of either style must be in perfect alinement to be effective. Casement windows are usually narrower than double hung windows. They have the advantage of a single sash but the objection to the meeting rail of the double hung window is more than offset by the stability of the vertical arrangement of the sash.

CEILING. The interior overhead surface of a room or compartment, usually formed of a lining of some kind affixed to the under side of the joists of the floor above, or to rafters. In modern buildings it is usually finished with or formed of lath and plaster work. A type known as a drop ceiling is sometimes continued in finish down to a horizontal rail around the wall, sometimes the picture mold. See Brace Mold.

CEILING, COVERED, FLAT. A ceiling which arches from the side walls but has a relatively broad flat central area.

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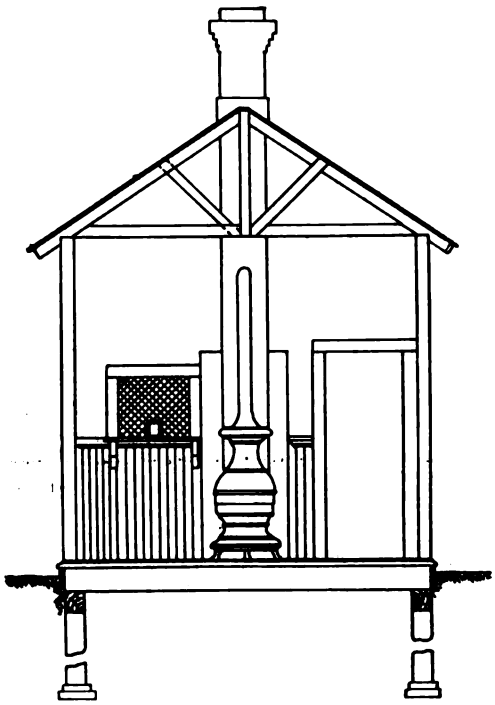
CHIMNEY. That portion of a building which contains the smoke flues, especially an upright masonry tube or flue usually extending through the roof and having flue openings for smoke pipes to enter at any convenient height.



Sketch Showing Location of Chimney in Frame Building

The chimney is usually located at an intersection of walls or against a wall, and is built to a height sufficient to afford free egress of smoke above surrounding buildings, etc. Chimneys are usually lined with special bricks or heat resistant flue tiles. Power plant chimneys are built high above surrounding structures to properly dispose of the gases emitted in the upper air as well as to afford suitable draft. See Flue (Building).

CHIMNEY SHAFT. The upper portion of a chimney which is above the roof. A chimney shaft is carried several feet above the highest portion of the roof to afford a sufficient draft to the flue. It is frequently necessary to extend it higher to overtop roofs or walls of adjacent or neighboring structures.

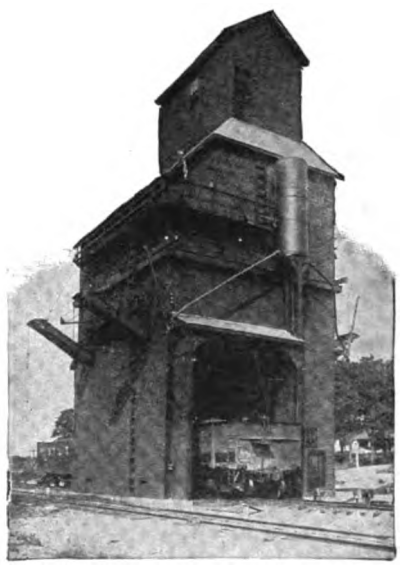
CLOSE STRING. A method of finishing the outer edge of a staircase by building up a sort of curb string on which the balusters are designed to set, the treads and risers also stopping against it. See Baluster.

COAL-TAR PITCH. Any of the heavier distillates of bituminous coal. It is not acted on by water, is readily affected by changes in temperature and is ordinarily used as it comes from the still in the manufacture of ready roofing shingles and built up roofings. See Roofing.

COALING STATION, LOCOMOTIVE. A place where coal is prepared, stored and delivered into the tenders of locomotives when required, by means of suitable structures and machinery.

The design of a coaling station depends on the manner in which the fuel is received, the estimated storage required ,and the rate of delivery to locomotives. While uncertainties of delivery influence the storage required, the expense of rehandling coal from storage to the locomotives is an incentive to minimize the amount stored or to arrange to load an engine direct from storage.

Frame Coaling Station
The Roberts & Schaefer Co.
(See Page 792)



Frame Coaling Station
The Bay City Foundry & Machine Co.
(See Page 656)

A common kind of coal handling plant includes an elevated timber trestle with an inclined approach, combined with one of the several styles of delivery devices, such as cranes, dump cars or gravity bins.

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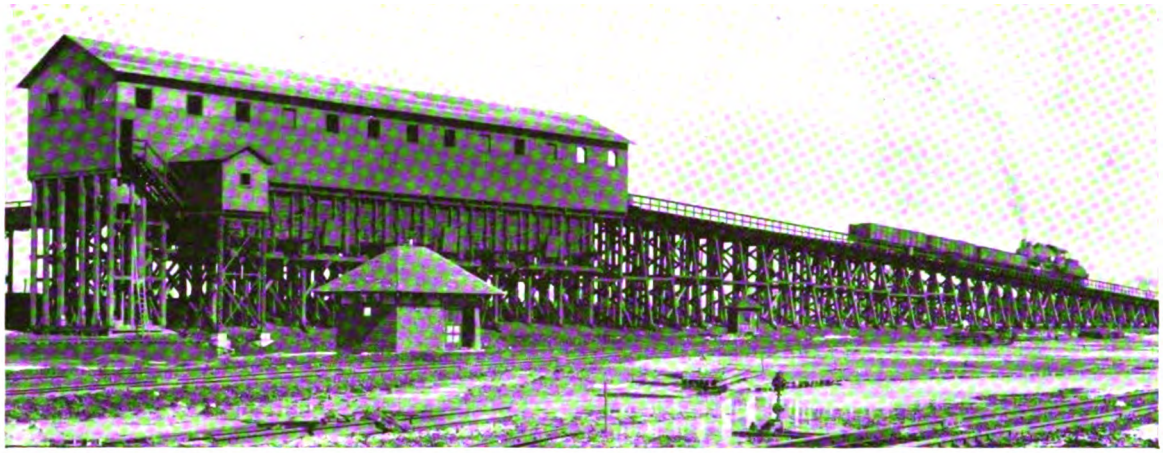

Frame Coaling Station with Inclined Trestle Approach

Frame Coaling Station with Undercut Gate and Sway Spout
The Ogle Construction Co.
(See Page 760)

Steel Coaling Station with Sanding Attachment
The Ogle Construction Co.
(See Page 760)

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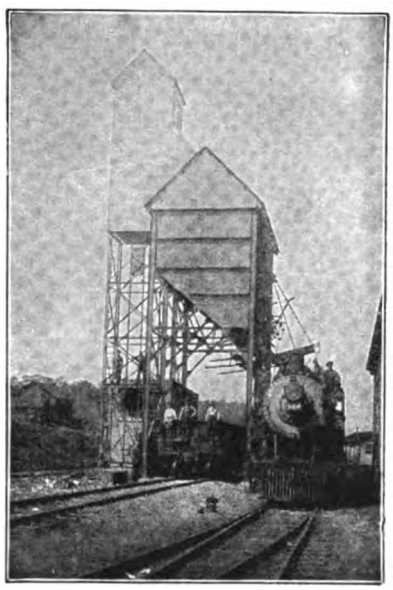
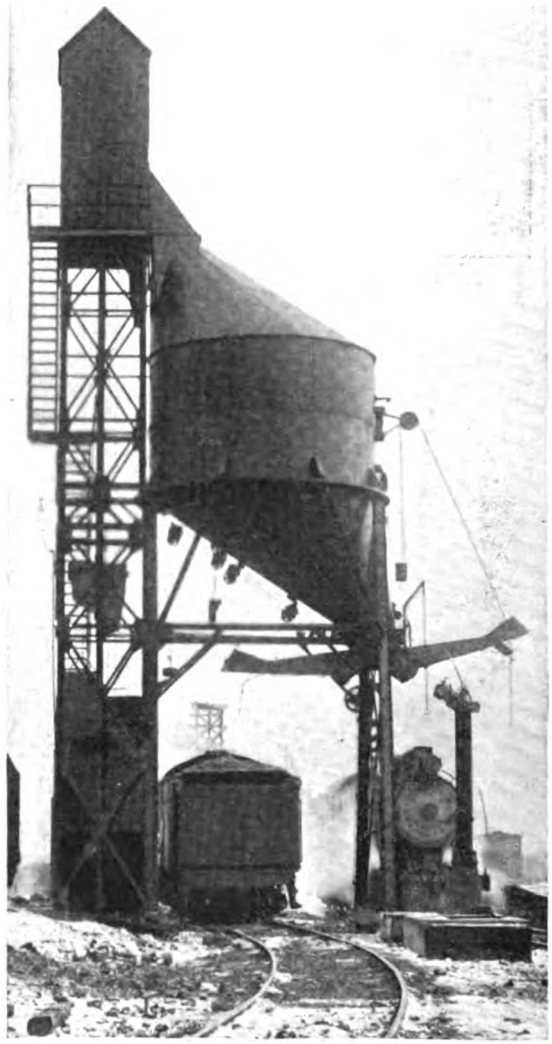
Steel Coaling Station
Fairbanks, Morse & Co.
(See Page 686)



Steel Coaling Station
Bay City Foundry & Machine Co.
(See Page 656)



Steel Coaling Station
The Roberts and Schaefer Co.
(See Page 792)

To handle the fuel mechanically from the cars in which it is received into the locomotive tenders, the coal trestle is built high enough to permit the unloading from the car on the trestle into a hopper bottom bin beneath the track, subsequent delivery being made through the hopper to the locomotive tender. The design of such a plant is restricted to sufficient height to obtain gravity delivery and bin capacity. Such coaling trestle, which may be 50 ft. or more above the tracks, is provided with an inclined approach on a grade suitable for locomotives if possible. In case so long an approach is not feasible or desirable, a stationary engine is installed under the trestle and used to hoist the cars by cable up a much steeper incline, sometimes on a grade of 10 per cent. The coaling trestle is strongly built with spans usually 12 ft. to 14 ft. long, designed to bear the weight of full bins between the bents as well as locomotives and loaded cars on the deck. The spaces between the stringer chords are left open for

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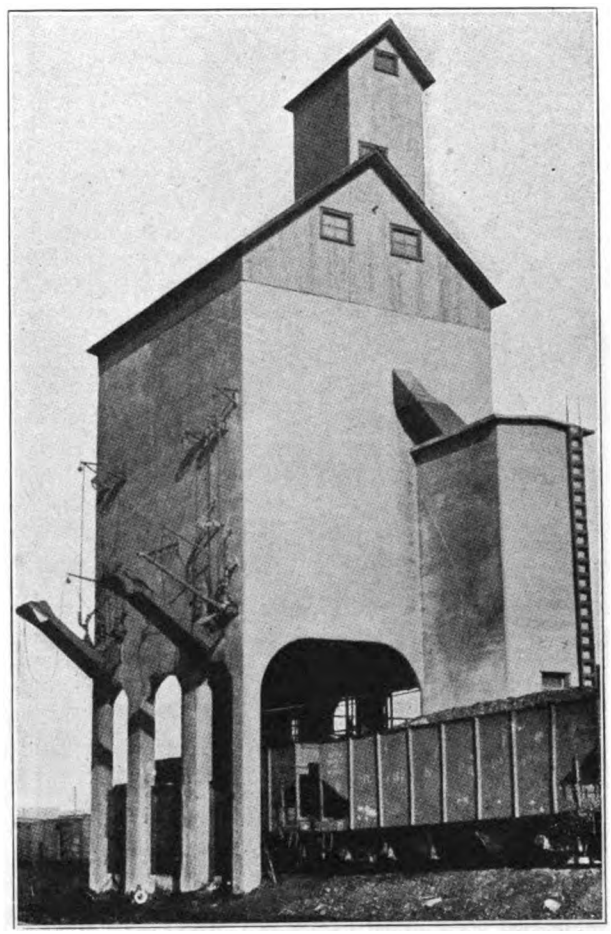
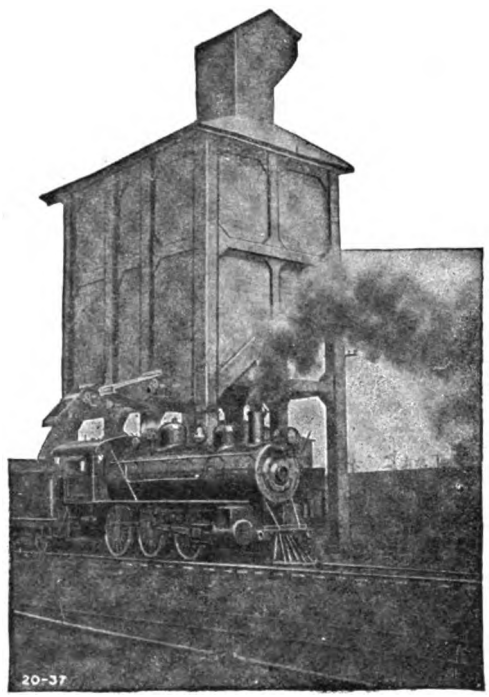
Steel Coaling Station
The T. W. Snow Construction Co.



Reinforced Concrete Coaling Station and Sand House
The Roberts and Schaefer Co.
(See Page 792)

coal to fall through, only beveled ties over the caps and sometimes one or more between bents extending across the opening. The bins are rectangular in top cross section, their floors sloping down to any wall at angles of 45 deg. or steeper to the delivery chutes, or the floors may be V-shaped or pyramidical to deliver fuel directly beneath the trestle. The usual arrangement is to put the coaling plant on a spur track with a coaling track on each side or on only one side, the bin floors declining toward this track where the engines are placed for coaling. At the bottom of the inclined floor of the bin a gate in the wall may be operated to release coal into a wide movable spout or metal chute which is balanced by counterweights and can be raised to close or pull down to open and deliver coal to the tender.

While this type of coaling station is fairly effective, the maintenance is considerable and the operation, requiring cars and loads to be hauled up the steep incline is not ideal from the standpoints of



Concrete Coaling Station
C. W. Hunt Co., Inc.
(See Page 711)

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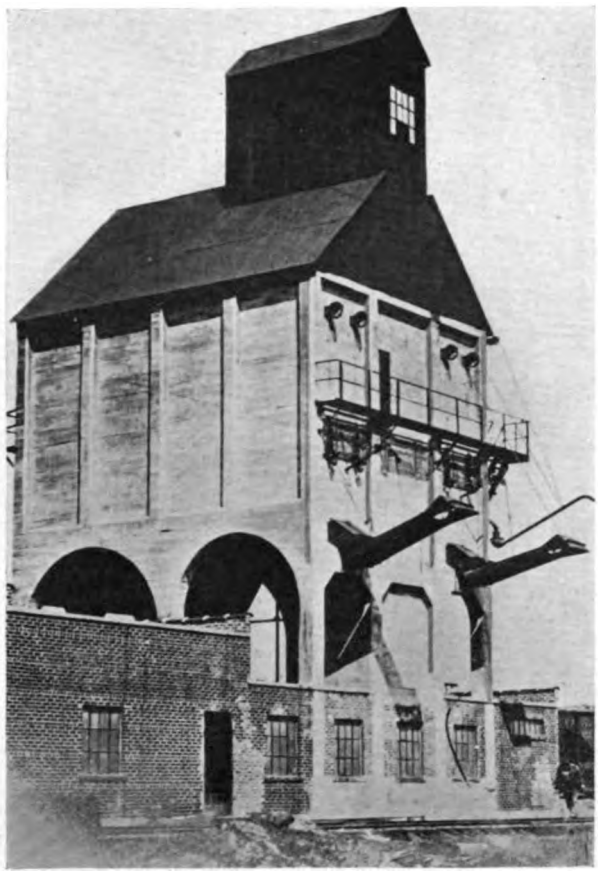
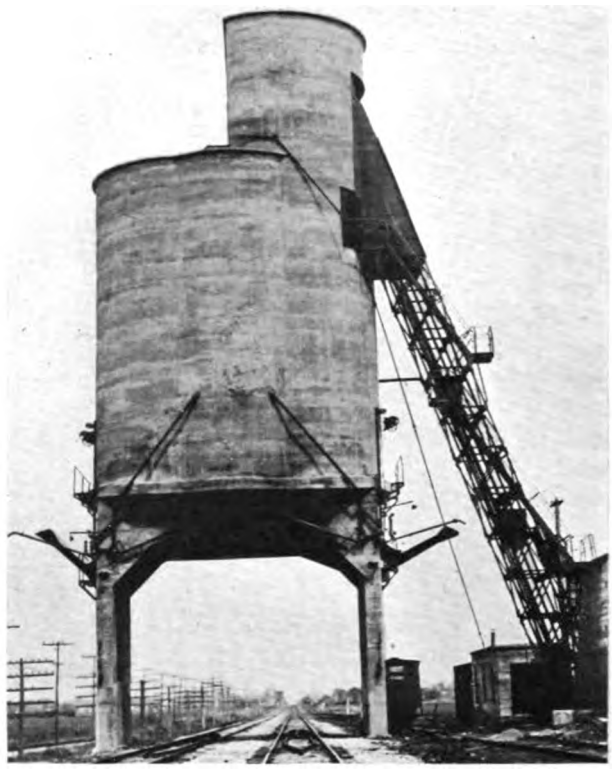
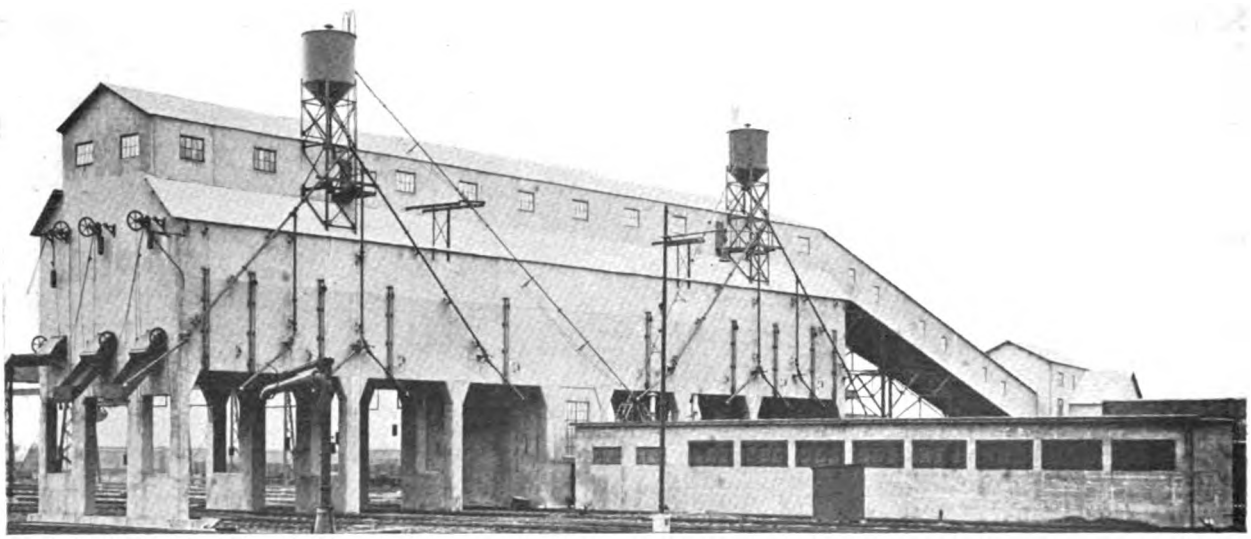


Rectangular Reinforced Concrete Coaling Station with Steel Roof
The Ogle Construction Co.
(See Page 760)



Cylindrical Reinforced Concrete Coaling Station with Inclined Outside Elevator
The Ogle Construction Co.
(See Page 760)



Large Reinforced Concrete Coaling Station

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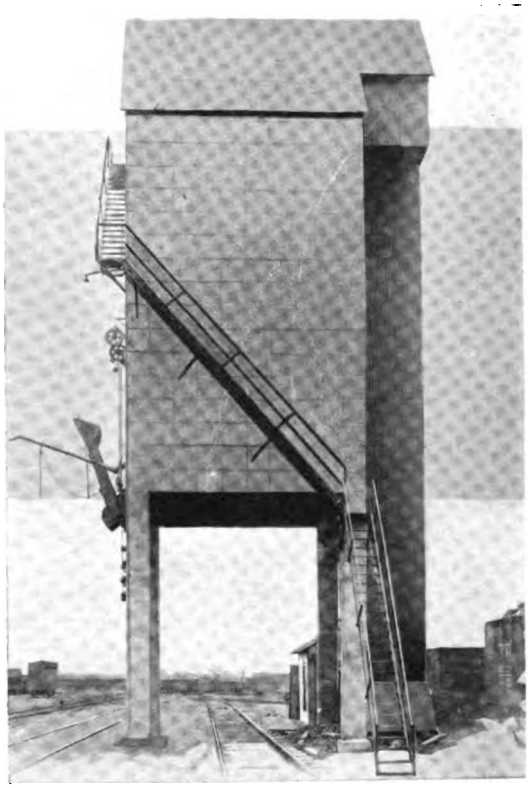
economy and safety. A later type which is now in general use on many railways is the coaling elevator. This device is a tower with a depressed hopper into which coal is dumped from cars on the receiving track, whence it is loaded in a counterbalanced bucket or in a series of conveyor buckets and lifted to the top of the tower by means of a wire rope or a conveyor passing over a rotary device near the top and around another attached to the floor of the receiving hopper. At the top the load is dumped automatically to one side into an elevated hopper-bottom delivery bin. The elevator may be arranged to deliver coal into any one of several delivery bins serving coaling tracks beneath or on any side of the



Concrete Coaling Station
Fairbanks, Morse & Co.
(See Page 686)

plant, each bin or compartment being supplied with a bottom gate and a counterweighted delivery spout through which the fuel is deposited by gravity in locomotive tenders.

Some bins are rectangular in mid-section with angular hopper bottoms, while others are round with conical bottoms. The elevator walls are usually enclosed in cold latitudes, but in warmer climates they are frequently open all or a portion of the distance below the dumping chute. The receiving hopper requires a deep foundation for a bin of medium capacity. In localities where deep foundations are impracticable or undesirable, the usual depth of 16 ft. below the receiving track level may be reduced about one-third by substituting a special shallow receiving hopper and a device for feeding coal to the conveyor. As in all hopper-bottom containers, the shape of the coaling bin and the slopes of the discharging floors are designed with a view to minimizing friction and assuring a free flow of coal. Coal tends to adhere to and accumulate on rough surfaces, especially in corners and at changes of slopes, sometimes choking a bin and preventing delivery until it is loosened. The inside surfaces of bins are made as smooth and with as few acute angles and changes in slopes as possible to obtain freedom in delivery.

The severe service to which these tall structures are devoted requires substantial construction. The foundations, including the receiving hopper, are usually made of concrete. The depth of the floor is frequently below the level of ground water, requiring that the walls and floor be thoroughly waterproofed. The entire superstructure is frequently made of reinforced concrete with the advantage of permanency and minimized maintenance. Metal superstructures are also used frequently, an advantage being the circular form of steel bin and the conical hopper with smooth surfaces. Wooden frame elevators are not so permanent, but the hopper floors are usually made of concrete or covered with steel plates, while inside vertical sheathing is commonly used to enclose the bins, the initial cost of construction being comparatively light, and intelligent maintenance going far toward extending the service life of such a plant.

While any available power may be used to operate a coaling elevator, the internal combustion engine is a suitable type, especially for intermittent hoisting where an independent unit is necessary. Where electricity is obtainable it is frequently cheaper and more desirable than any other power; but with any type, auxiliary power is desirable in case of possible break downs.

Devices to measure and weigh the coal delivered are sometimes attached to the tower, the measuring device being usually located in the receiving hopper while the scale is placed at the base of the delivery bin.

Where mechanical cooling plants are not available, locomotive cranes are frequently used to deliver coal directly from the receiving cars into locomotive tenders, usually by means of clam shell buckets. This method is reasonably economical provided time is not lost on account of the requirements being intermittent. The crane also is used sometimes on an elevated track to transfer coal from ground storage bins to elevated coal pockets, while engines are also frequently coaled from ground storage supplies by means of steam shovels, cranes, ditchers or similar equipment.

Coal is sometimes stored at ground level, loaded by hand into 2-ton iron buckets, carried on push cars to a raised platform, elevated by means of a stationary derrick equipped with a compressed air cylinder and transferred in the buckets to the locomotive tender, the lifting power being obtained from the air pump on the locomotive. This method is used only where so few engines are regularly coaled that the installation of a power plant is not justified.

COAT. A layer of any substance such as paint, plaster, etc., applied at one time. In plastering, the first coat is called the priming or scratch coat while the second is called the brown coat (when three

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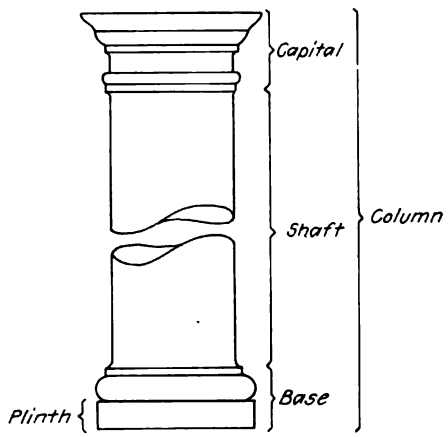
coats are used), the last being known as the slipped coat, skim coat, white coat or finish coat.

COLUMN. A vertical pillar usually consisting of a shaft, base and capital, each more or less ornamented according to the style of architecture. The capital of a column is generally surmounted with an entablature consisting of courses of various thicknesses and degrees of ornamentation while the base stands on another called the plinth. Of the



Sketch Showing Principal Parts of a Column

different classes of columns used in building all have bases except the doric, while in section they are either circular or segmental, with or without flutings or channels. They are said to be attached or engaged when they form part of a wall, projecting one-half or more, but not the whole, of the distance.

The column is primarily used as a plumb post or other upright structural support, its ornamentation being a secondary matter of architectural design, in which form it is usually employed in extensive buildings such as at entrances to terminal passenger stations, etc.

COMMON. A line, angle, surface, etc., in carpentry which belongs equally to several objects. For example: common centering is a centering without trusses having a tie beam at the bottom while common joists are beams in flooring to which the joists are fixed, and common rafters in a roof are those to which the laths are attached.

CONDUIT. A long narrow enclosed passage between two walls or an underground passage for communication between different structures, apartments or buildings. Smaller passages such as lines of hollow tile designed to carry and protect insulated electric wires under street pavements into interlocker towers, etc., as well as metal pipes carrying electric light wires, are also known as conduits.

COPING. The capping or covering of a wall with an otherwise exposed top, designed as a means of protection from the weather. The top is sloped to carry off water while the bottom is sometimes cut with a drip. While stone is sometimes used as coping, concrete or clay tile is now in extensive use. Without effective coping the exposed top of a wall may be penetrated gradually by moisture which extends downward into the core and tends to deteriorate the entire structure.

CORBEL (Building). A projection from the face of a wall supporting a weight set on it. A common form of corbel is a single stone or timber set in and projecting from a wall, or a projection consisting of courses of stones or bricks, each projecting slightly beyond the next lower course.

CORRIDOR. Any long passageway in a building opening out into rooms or apartments on either side.

A corridor is usually longer and broader than the type of passageway called a hall.

COUNTERSINK. To make a cavity in timbers or any other material for the reception of the head of a bolt or screw, a plate of iron, etc., in order that it may be flush with the surface.

To countersink a member neatly the depression must be of the exact form of the head of the rail. A rivet head is hammered while hot to fit the prepared hole.

D

DARBY. A plasterer's float, consisting of a thin strip of wood or metal ranging from 3 in. to 7 in. in width and 3 ft. or more in length. Two detachable handles are fastened on the back of the tool near the ends. This tool is designed to be used especially in plastering.

DEAD RAIL (Scale). One of the running rails of the dead rail track which passes over a track scale on fixed foundations, to carry rolling stock which is not to be weighed.

The dead rail track is gauntleted with the live rail track which is offset over the weigh bridge, terminating at switch points at the approaches to the scale on either side. In case of motion weighing the offset is divided.

One dead rail is carried on the pit wall or on floor beams while its mate is carried on a line of metal stands with rail chairs or bearings at their tops. These metal stands are set directly on the floor of the pit between the main lever pedestals. See Scale, Track. Also Live Rail, (Scale).

DEAD RAIL BEAM (Scale). A track scale floor beam extending from the pit wall into which it is built, for the purpose of supporting the dead rail. These beams are usually transverse I beams spaced 2 ft. 6 in. center to center.

DIRT SHIELD (Scale). A strip of steel plate about ⅛ in. thick and 6 in. wide laid over the crevice between the scale weigh bridge platform and the adjacent frame timbers to keep dirt out of the scale pit.

Dirt shield strips are in random lengths and have holes drilled about 1 in. from the outer edge at intervals of about 4 ft. Through these holes staples are driven into the framing timber about the edge of the scale pit, while the strips are unattached to the scale platform, and may be turned back on the staples as hinges, clear of the platform if necessary.

DOOR. A structure providing a filling for an opening made for entrance to and exit from a building or a room.

While doors are usually hung on hinges to the side of the opening or doorway they may also be made to slide, roll or lift or fold. (See Page 812).

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DOOR CASE. The frame or casing which incloses a door on its hinges and against which the door closes. It consists of two upright jambs and a top cross piece or head, generally fixed together by mortises and tenons and concealed by moldings, etc. Outside door-cases such as at the main entrance to a building have double beveled surface thresholds or sills which serve as means of preventing water from entering between the door and the floor.

DOOR FRAME. The structure forming the skeleton of a paneled or glass door. Ordinarily paneled doors consist of the stiles at the top and sides, bottom and one or more intermediate horizontal rails into which the panels are sunk and grooved. Glass door frames are similar except that the intermediate rail is not used where the glass sash extends the full length between the top and bottom rails. Glass door sash may have wooden mullions or loaded divisions between the panes of glass.

DORMER WINDOW. A roofed window projecting from a sloping roof and designed to furnish light to a room which extends above the eaves.

The window may be in the plane of the side of the main building or it may be entirely within the slope of the roof.

DOWN PIPE. A tabular drain pipe designed to carry water from the eaves of a roof to the ground or into a drain or sewer.

Down pipes are commonly located on the outside of and at opposite ends of a building if the roof is steep, while roofs that are nearly flat usually carry the water to a point at one end or near the middle, where the down pipe is located. Buildings having steeply sloping roofs are equipped with slightly inclined eave troughs, the lower ends being connected to the down pipe and the grade being calculated to permit the down pipe to carry off the water at the maximum rate of flow. In passenger stations, freight houses, engine houses, etc., where storm sewers are included in the drainage system, it is common practice to connect the down pipes of the various buildings to these storm sewers by means of iron pipe or sewer tile, while the ordinary roadside structures are sometimes equipped with down pipes which carry the water to the ground surface only.

The sizes of down pipes depend largely on the area and slope of the roof and the eave troughs. Ordinarily a 3 in. to 4 in. metal down pipe is sufficient for the common roadside structure, but for terminal structures, the roof areas of which are generally large, several down pipes 6 in. or more in diameter are sometimes necessary. Tin, pure iron and galvanized iron are the metals most commonly used for down pipes, while iron pipe frequently replaces the lighter metal from the ground surface to a height of about 6 ft. above the platforms of stations where protection against the wheels of baggage trucks is necessary. See Gutter (Building).

DROP PIT. A pit in the track inside of the engine house in which machinery is located for dropping wheels from under locomotives. (A. R. E. A.)

The drop pit extends across and between two or more engine pits in the stalls, and is provided with a power jacking arrangement supporting two short sections of rails which may be used to span the drop pit and complete the lines of rails over the engine pit or turned with the wheels on and lowered into the drop pit at right angles to the engine pit.

Drop pits are commonly made of concrete or other masonry, their bottoms being about 4 ft. or more below the floor line of the building. A drop pit may connect two or more pits, frequently three, angles in the walls being made between engine tracks to keep the course of the pit at right angles with each engine pit at its intersection.

DWELLING. A house occupied as a residence, with any structures connected directly to it or communicating with it by means of inclosed covered passageways, as distinguished from buildings or houses used for other purposes, such as shops, station houses, signal towers, etc.

Section houses and agents' quarters are dwellings often supplied by railway companies for the use of employees. See Building. Also House.

E

EAVES. The lower borders of a roof which overhang the walls and cast off the water which falls on the roof.

ENGINE HOUSE. A structure designed for the shelter and general maintenance of locomotives in service. (A. R. E. A.)

As to design, an engine house is a one-story structure with tracks leading into and extending nearly the entire depth of the building, engine pits being located between the rails of most of the tracks. The house may be (1) rectangular in plan or (2) polygonal. The first design is seldom employed and then usually for small structures built for the accommodation of a few locomotives or where a turntable is impracticable or undesirable. Rectangular houses are made longer than the longest locomotive which the best judgment indicates will be used in the territory served during the life of the house, sometimes so long that two or three engines may be housed on one track. A difficulty with this type of house is to provide the proper approach tracks, unless a ladder track or a transfer table is used, either of which is usually too expensive for small terminals.

The polygonal house, arranged with the points of the bays in the arc of a circle, around a central turntable, is commonly known as a round house, each radial track serving an engine stall. The house is designed for locomotives to head in, with their front rails facing the outer circle in the walls of which large windows are placed to afford the best possible light in each bay, while doors in the inner circle are provided with sash or transoms or both to light the inner half of the house, when the doors are closed. Smoke jacks which afford an outlet for smoke and gases from the locomotive stacks, are located in a line along the roof near the rear of the house, while a corresponding row of ventilators is placed in the roof near the inner circle. The roof may be in one plane, sloping slightly down toward the outer circle to take the drainage away from the front (where ice might form on the tracks in winter

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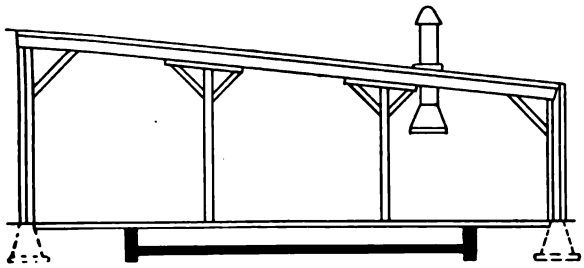
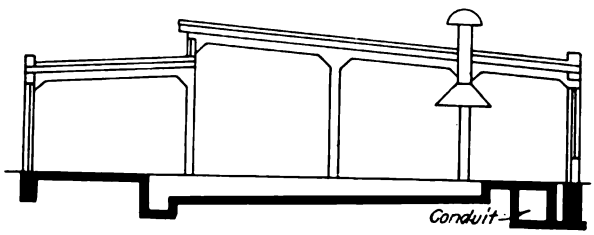
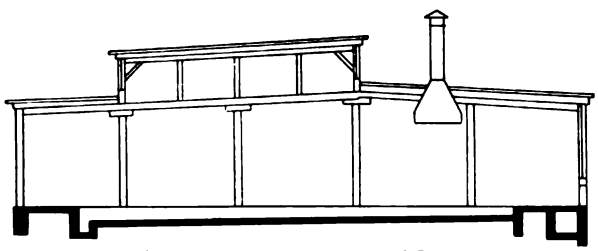
and prevent the swinging of the doors), or if the house is so long that this difference in elevation from front to back is undesirable, the roof may be



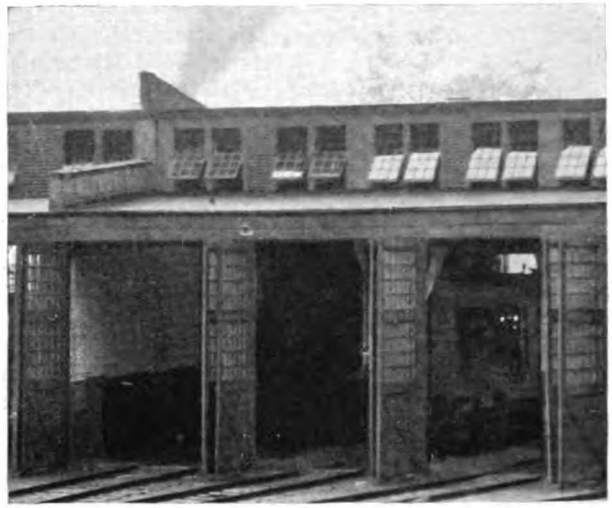
Radial Engine House with Plain Roof



Radial Engine House with Double Slope Roof



Engine House, Central Roof Lighting



Frame Round House Showing Fire Wall

broken by a transverse valley, usually over the first row of roof supports from the inner circle, with inside down pipes. Another type of roof is peaked, with symmetrical or unequal slopes and with or without a leanto. It may have a monitor centrally or otherwise located or a clere story, the light from the top thus obtained being desirable to dispel shadows within the house.

While the roofs are nearly always supported on lines of posts as well as on the circle walls, some are designed to be carried from wall to wall without intermediate posts. The simplest roof is usually most desirable and economical, the chief difficulties of design resulting from the problems of maintenance. The one-slope engine house roof may be classed as a flat roof with only sufficient pitch to afford drainage, usually less than 3 in. to the foot. This wide flat outside surface is exposed more directly to the elements than a roof of steeper pitch, while the under side must resist the corrosive action of smoke fumes and condensing steam. The roof covering commonly consists of extensive units with weather proofed joints or of continuous built-up roofing. The severe service conditions, the impor-

Rectangular Frame Engine House

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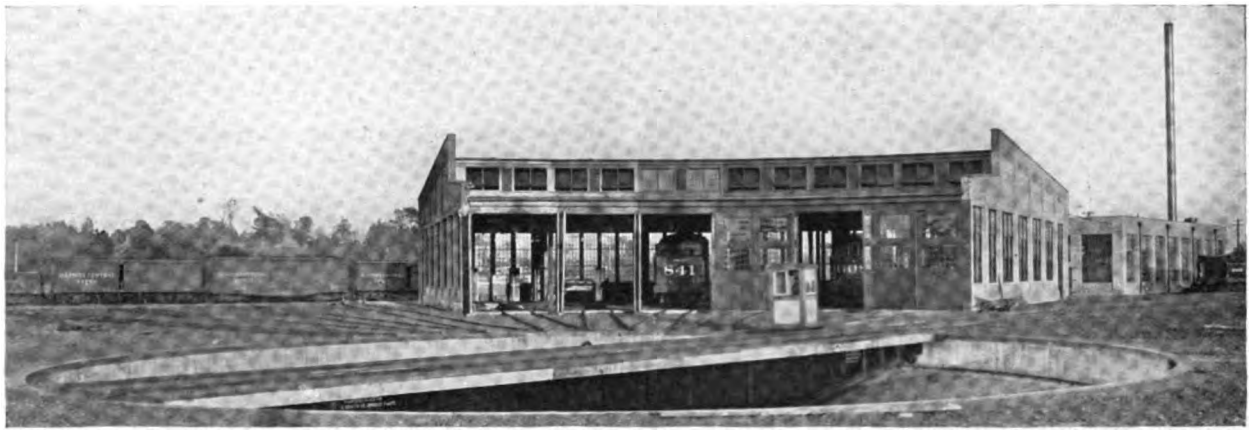
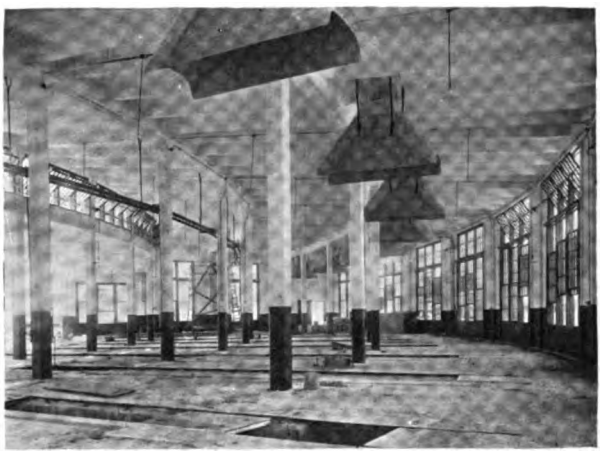


Brick Engine House with Power Plant in Background



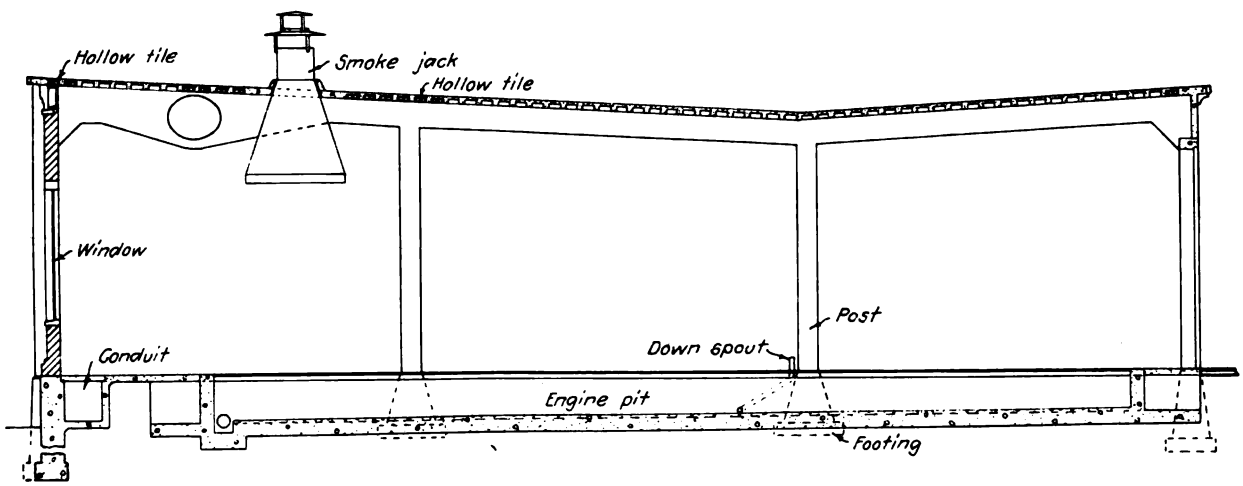
Reinforced Concrete Round House

tance of maintaining a water-tight surface and the difficulties of renewal suggest permanence as an element of economy in roofs and roofing, as well as in flashings, framing, the laying of roof boards and other details of construction.

Engine pits are made nearly as long as the longest locomotives, the floors are crowned, the walls are designed with consideration for insets for steam pipes if any, and bearings for the jacking of locomotives; while the depth is varied to slope the floor and obtain drainage toward the inner circle at which end screened outlets are provided to lead water into the circle drain, usually carried in a conduit below the floor, along the walls of which water and other pipe lines are frequently carried.

The floor of the house between pits is crowned and is preferably of permanent materials. Drop pits, constructed to cross and intersect the engine pits for the purpose of handling and exchanging engine wheels and tender wheels, are usually built in pairs as a matter of economy and as a detail of the foundation work.

The engine doors of the inner circle, usually serving doorways about 14 ft. wide by 17 ft. high, may be rolling lift, bifold, or hinged double doors. An advantage of the rolling lift door is that it affords



Concrete Engine House, Duluth & Iron Range

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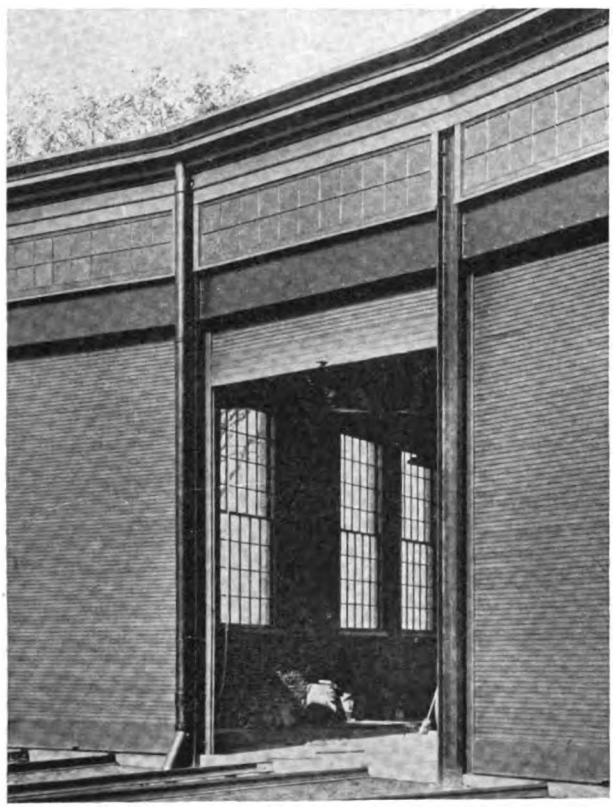
a maximum side clearance when open, while there is no necessity for cumbersome closing devices. The bifold door also opens upward and requires no side room. There is not room between door posts to use side sliding doors but double hinged doors are in general use in the engine houses of many railways. They swing outward, the top panels being usually occupied by single sash while the lower panels are filled with dressed and matched ceiling, three or four hinges being required on each door. When closed each pair of doors is secured by an inside lever attachment. A wicket door is usually placed in a lower panel of one double door in each section which consists of about 10 stalls included between fire walls or between the fire wall and end wall. An automatic sliding fire door is preferably hung on each surface of a fire wall while single doors are usually placed in each radial end wall of the house.

Double hung engine house windows are designed to afford all the light possible to the interior and they usually occupy most of the outer circle wall space between columns, sometimes in groups of three to five, swinging or pivoted sash being frequently inserted for ventilation. The standard prac-



Rolling Wood Door
The J. G. Wilson Corporation
(See Page 840)

tise of the A. R. E. A., applying to the design of new engine houses, is as follows:

Engine House Design

Form. (a) The circular form is preferable.

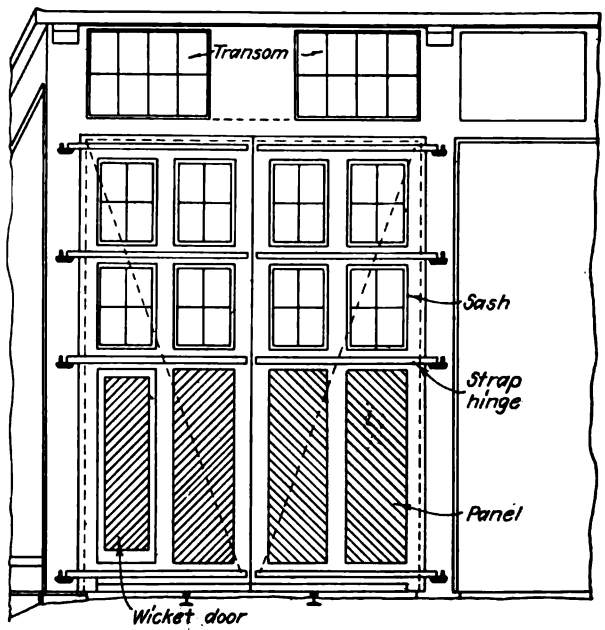
(b) At points where not more than three or four locomotives are housed at one time, and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn locomotives, a rectangular house, either with through tracks or with switches at one end only, may be desirable.

(c) At shops where a transfer table is used, a rectangular engine house served by the transfer table may be desirable.

Turntable. (a) The turntable should be long enough to balance the engine when the tender is empty.

(b) A deck turntable is preferable to a through table.

(c) At important terminals, turntables are most economically operated by mechanical means. Where few



Sketch of Engine House Door Showing Parts

and light engines are turned, hand operation may be desirable.

Where electric power can be obtained at a reasonable cost, an electric tractor is the most efficient means for operating a turntable, the cost of power is cheaper, and it is superior in continuity of service and maintenance. The first cost is approximately the same as an air motor of equal power and size.

Power wires are brought to the table by either the overhead or the underground method. Overhead device has the advantage of accessibility for inspection and repair. Special care must be taken to properly protect collector head from weather and gases and support collector rigidly (framework supporting same should be fastened to steel frame of table and not to ties, and must be securely braced); the wires should be large enough to keep them from breaking from sleet and should be supported to framework supporting collector. Any play at table multiplies at collector head. Wires should be brought to pole, close to curb of turntable, keeping lines as far distant from nearest wall of roundhouse as possible, to minimize the danger of destruction by fire.

When the underground system is properly installed, its advantages are that all exposed, non-current carrying parts are permanently grounded, including the circular-track rail (the only part of system to repair is collector head); non-interference from weather if the turntable pit is properly drained.

The disadvantages are: the wire is not so easily repaired, and is much more difficult to originally install, as it must be properly protected from water, and cannot be successfully laid in a fill or on ground where settlement or shifting takes place. Where the turntable pit cannot be well drained, it cannot be used with success. It has the advantage of protecting power to run the table in case of fire in the roundhouse, especially in one of a nearly complete circle. Compressed air tractors are frequently used. Ordinarily the power

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costs much more than electricity and is not so reliable. At points having no power plant the locomotive to be turned furnishes the compressed air; in this case an auxiliary supply should be maintained by providing a small air tank secured to the turntable for operating it before or after the engine is placed.

(d) The deck on the turntable should be wide enough to provide a walk on each side and be protected with hand rails.

Turntable Pit. (a) The turntable pits should be well drained and preferably paved.

(b) The circle wall should be of concrete or brick, with proper supports and fastenings for rails on the coping.

(c) The circle rail should preferably bear directly on the concrete base. The use of wood ties and tie plates supported by masonry is desirable under some conditions.

(d) Easy access to the parts of a turntable for the oiling of bearings, painting and inspection should be provided in the design of the turntable pit, unless ample provision is made in the turntable itself.

Door Openings. The clear opening of entrance doors should not be less than 13 ft. in width and 16 ft. in height.

Doors should be easily operated, fit snugly, be easily repaired and maintained, and should admit of the use of small doors.

Tracks. (a) Lead tracks to the turntable should line up with tracks of the engine house where possible.

(b) Tracks should be on level grade and should be provided with stop blocks.

(c) Special fastenings of the track rails at the circle wall and on the turntable are desirable to prevent movement of the rails, to give good bearing and to lessen the damage from derailed wheels.

Position of Locomotive. In a circular house the locomotive should stand normally with the tender toward the turntable.

Length of House. The length of stall along center line of track should be at least 15 ft. greater than the over-all length of the locomotive, to provide a walkway behind the tender, a trucking space in front of the pilot and a certain distance in which to stop the locomotive or to move it to bring side rods or other parts into convenient positions.

Materials. (a) The material used in construction of the house should be non-corrosive, unless proper care be taken to prevent corrosion.

(b) The additional security against interruption to traffic from fire warrants serious consideration of the use of a fireproof roof, and dividing the engine house into units of approximately 10 stalls by the use of division walls built of fireproof material.

(c) When the roof is of reinforced concrete the columns and roofbeams should be of the same material.

(d) Reinforced concrete should be used for the walls only where special conditions reduce its cost below that of brick or plain concrete, and should not be used for that portion of the wall directly in lines of track where engine is liable to run into it.

Engine pits should be not less than 60 ft. in length, with convex floor, with drainage toward the turntable. The walls and floors may be of concrete, proper provisions being made for the support of the jacking timbers.

Smoke jacks should be fixed. The bottom opening should be not less than 42 in. wide, and long enough to receive the smoke from the stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The bottom of the jack should be as low as the engines will allow, and it should be furnished with a drip trough. The slope upward should be gradual to the flue. The area of the cross-section of the flue should be not less than 7 sq. ft., and the jack should be made of noncombustible material. (This design of jack applies to all houses where regulations will permit. In some cities, where smoke abatement laws are in force, special design of jacks are necessary.)

The floor should be of permanent construction. It should be crowned between pits.

Drop pits should be provided for handling truck, driving and trailer wheels.

(a) Heat should be concentrated at the pits.

(b) The general temperature of the engine house should be kept between 50 deg. and 60 deg.

(c) The recommended method for heating is by hot air driven by fans through permanent ducts, which should be under the floor where practicable. The outlets should be fitted with dampers so that heat can be cut off while men are working in the pit. The fresh air supply should be taken from the exterior of the building and no recirculation allowed. It should be delivered to the pits under the engine portion of the locomotive. It should be heated as far as possible by exhaust steam, supplemented, as required, by live steam.

Window Lights. (a) The disadvantages of skylights are so much greater than their advantages as to make them undesirable.

(b) Windows in the outer walls should be made as large as practicable with the largest glass or light area consistent with the requisite strength. In general, the lower sill should be not more than four feet from the floor, and only sufficient space left between pilasters and sides of window frames and girders and window heads to properly secure the window frames. Windows or transoms as large as practicable should be provided over all doors where locomotives enter. Window lights in doors are objectionable on account of difficulty of maintenance.

Electric Lighting. General distribution of illumination should be provided between pits by arranging a number of lights to avoid shadows and to give good light for workmen at the sides of the locomotives. There should be plugged outlets for incandescent lamps in each alternate space between pits.

Piping. (a) The engine house should be equipped with piping for air, steam and water supply, and where desired, piping for a washout and refilling system should be installed. Where this system is installed, the blowoff lines should be led to a central reservoir; where it is not used, the blowoff lines should be led outside the house.

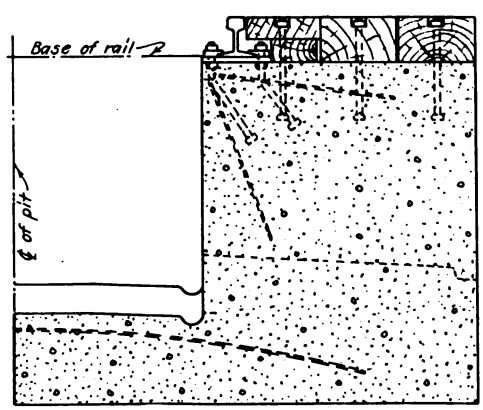
(b) The steam outlet should be located near the front end of the boiler. The blowoff pipe, the air, the washout and refilling water and the cold-water connections should be near the front end of the firebox. Connections need only be provided in alternate space between stalls.

Tools. There should ordinarily be facilities provided for hand tools and for the location of a few machine tools, preferably electrically driven.

Hoists. Hoists with differential blocks are generally used for handling heavy repair parts, and suitable provision should be made for supporting them.

ENGINE PIT. A pit in a radial track inside an engine house designed to facilitate the repairing and cleaning of the running gear under an engine. (A. R. E. A.)

Engine pits are constructed between the rails of the tracks on which the locomotives are housed.



Section Across an Engine House Pit

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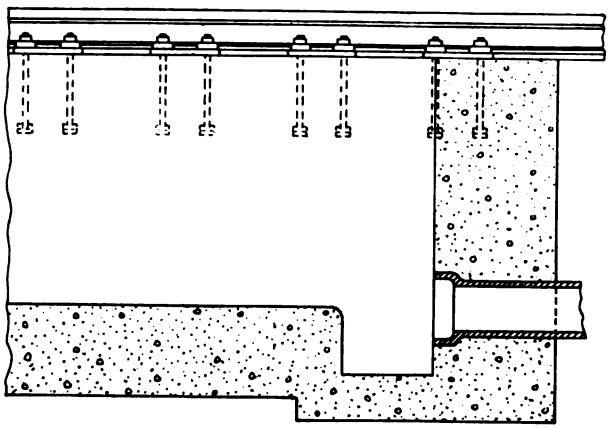
Usually all such tracks in a house are supplied with pits which are usually more than 60 ft. long and made of concrete or other masonry. The floors are crowned to drain to the walls and laid on grades declining toward end outlets. The walls are sometimes heavily coped to provide insets for steam heating pipes which are hung to fixtures close to their



Section Along Center of an Engine House Pit

inside surfaces. The track rails are fastened on the pit walls on wood blocks, metal chairs or by some similar device. In building engine pit walls extra thick sections are usually provided to afford bases for timbers and jacks used in raising locomotives off their wheels, etc., for repairs. See Engine House.

ENGINE TERMINAL. One or more buildings with facilities for the housing, supply and general maintenance of locomotives in service, consisting of an engine house and auxiliary structures, and sometimes including a back shop for heavy locomotive repairs.

The engine terminal is located at some point near where the runs terminate as at a division point, and preferably in the neighborhood of a large switching yard where trains are made up. The structures commonly included are the engine house, usually built on an arc of a circle to bring the tracks in positions radial to a central turntable, a power house, a storehouse for supplies, an oil house for oils and lubricants, a coaling station, a water station, an office building and such trackage as is necessary to group these facilities for use in proper sequence for incoming and outgoing locomotives.

The tracks serving the engine terminal usually diverge from incoming and outgoing leads, all the terminal facilities preferably being on one side of the main track and not separated by any other than the service tracks of the group. The ash pits are close to the water columns, which should be first available to incoming engines while the sand chute is opposite or close to the coaling station which should be used by outgoing engines to start the run with a full supply of fuel and which is adjacent to the coal storage space, these facilities all being between the lead track switch and the engine house. The store, shops and supply yard are commonly located behind the engine house on a lead from the direction opposite to that from which the locomotives arrive at the turntable. A track which frequently extends through the engine house forms a connection with this lead which may also connect by another route with the tracks used by engines while coaling. A wye on which to turn engines in case of emergency is also preferably located in the near vicinity. If feasible the office building is placed in view of the front of the engine house. The shop and store buildings have platforms, the engine house is sometimes provided with an overhead crane, traveling on a curved track near the outer circle, for which the roof is specially constructed; the cinder pit preferably is supplemented by ash handling machinery and the coal storage may be arranged for mechanical transfer of coal to the coaling bins. A blower system may be installed in the engine house and shops to supplement the ventilation obtained through smoke jacks and roof ventilators. The turntable and transfer table are frequently moved by power, as by electric motor attachments. Permanent materials are preferably used in all these structures unless they may be temporary for some reason. See Engine House. Also Oil House. Also Coaling Station, Locomotive.

ENTRY. A hall or passage without stairs or vestibule leading into a house or building or to a room.

An entry frequently serves the purpose of an anteroom, or a waiting room or a place where baggage or wraps are left.

EXTENSION LEVER (Scale). One of a series of horizontal longitudinal levers bearing on lever stands placed on pedestals on the center line of the scale pit floor.

The noses of the main levers are looped to the extension levers, thus transferring the loads while the noses of the extension levers are held in line and similarly connected. In a four section track scale there are four longitudinal extension levers extending the entire length of the scale beneath the center line of the weigh bridge, which are known as end and middle extension levers. There is also one transverse extension lever which extends from a center line connection of the middle extension levers out to one side under the weigh house to a connection with a vertical rod which transfers the loads to the shelf lever.

F

FACE MOLD. A template or pattern used by carpenters for outlining the forms to be cut out from boards, sheet metal, etc., such as ornamental handrailings for stairs, etc.

FINIAL. Any ornament placed on top of the hip of a roof or on the apex of a gable to give an artistic finish to the structure, sometimes called a hip knob.

FIRE DOOR. A door of metal or other heat-resisting material used to prevent the spreading of fire from one room or building to another.

A fire door is commonly used to protect the doorway in a fire wall separating adjacent rooms or buildings. A fire wall, usually of thick masonry construction, extending from the foundation to the coping above the roof, is made without openings

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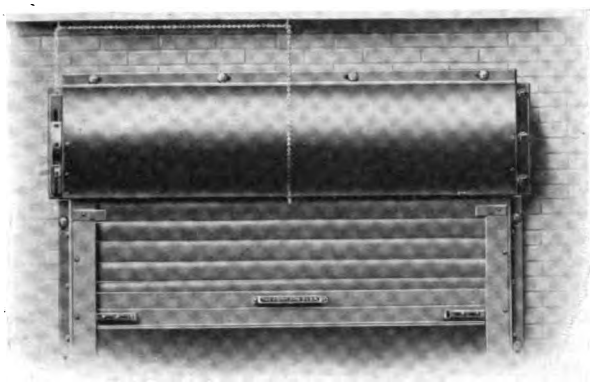
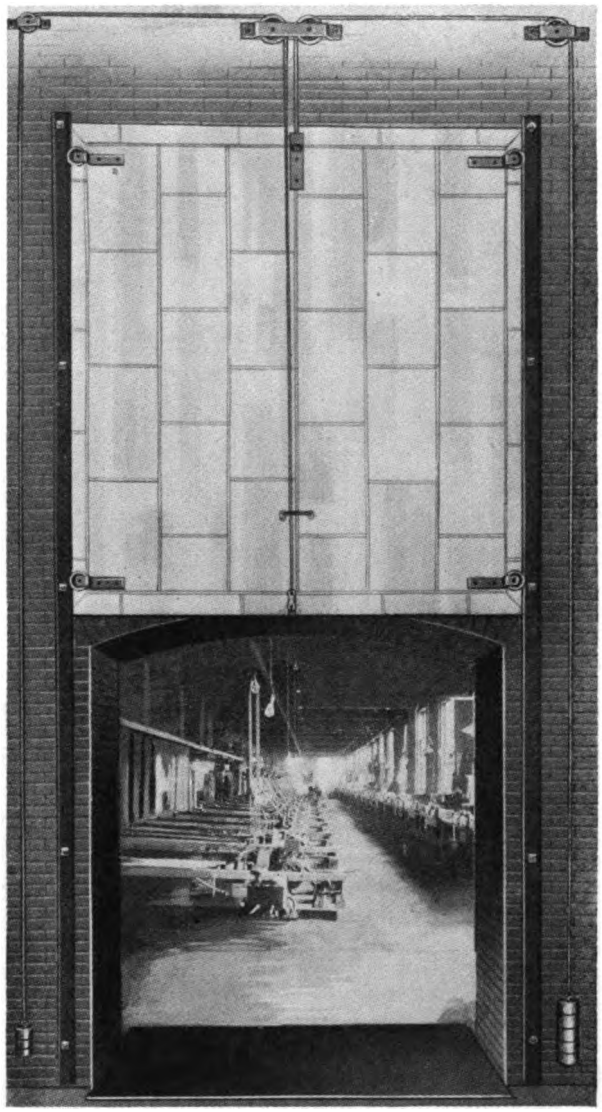
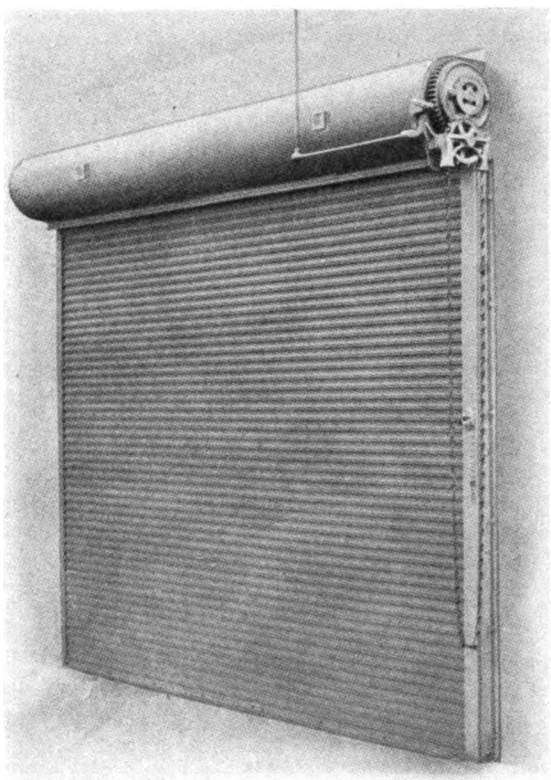


Underwriters' Fire Door
The J. G. Wilson Corporation
(See Page 840)



Vertical Sliding Door
The Richmond Safety Gate Co.



Fire Door for Openings in Fire Wall
The Kinnear Manufacturing Co.

Sliding Fire Door
The Merchant & Evans Co.

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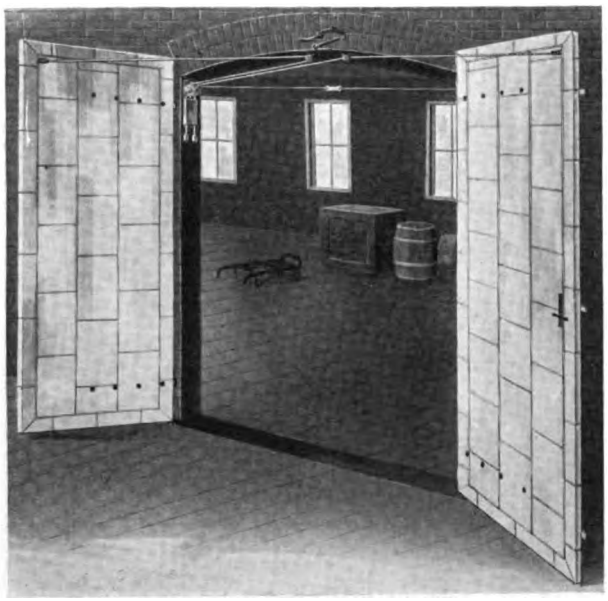
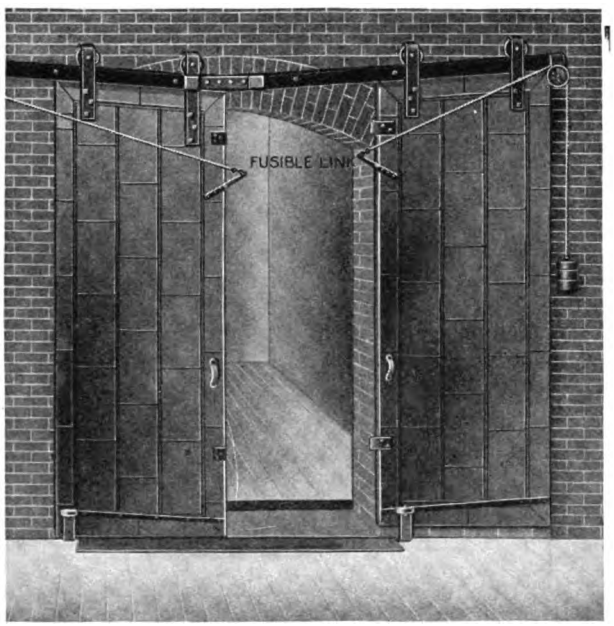


Double Swinging Door
The Richmond Safety Gate Co.



Double Inclined Sliding Fire Door
The Colburn Trolley Track Manufacturing Co.

if feasible, but where large buildings such as engine houses and freight warehouses are divided in sections by fire walls to confine possible conflagrations to one portion of the structure, doorways must be provided for trucking, etc., and in such cases fire doors are necessary to complete the protection.

Two fire doors, one on each side of the wall, are usually required to afford the best protection, equal to that of the wall itself. These doors, the thickness of the wall apart, are usually of metal, of wood encased in metal, or of asbestos and metal. Some types consist of two thicknesses of corrugated galvanized steel, generally interlined with sheet asbestos and surrounded with a continuous rigid steel frame, or of wooden panels covered with flat or corrugated steel sheets. They are single or double, rectangular or solid and usually without ornamentation. They are made to either overlap the doorway or fit flush with the wall. They preferably are arranged to close automatically, frequently sliding on an inclined overhead trolley rail, although other types are swung on hinges, or rolled or lifted in various ways. Various devices are used to raise and lower, or to open and close them mechanically by means of counterweights or by a roller arrangement placed above the opening in the wall, the door sometimes being equipped with a closing device which is automatically actuated by a fusible link.

When used for outside doors they are sometimes designed to slide vertically up the inside face of the wall by means of counterweights and trolley wheels fastened to the door case. For engine houses a flexible steel door is sometimes used, consisting of concave or flat interlocking steel slats fitted with alternate end locks, the flexible joints of which permit flexure and allow the door curtain to roll up without buckling. See Fire Wall.

FIRE WALL. A wall designed to completely isolate and prevent the spreading of fire from an adjoining area into the room or the structure which it protects.

A fire wall is usually a substantial masonry division wall 12 in. or more in thickness, extending from the foundation to a point above the surface of the roof, and from out to out at the ends of the building in order to provide a complete barrier against fire. Only the most necessary doorways and window openings are allowed in a fire wall and they are protected by means of fire doors and shutters, preferably made as impervious to heat as the wall itself. See Fire Door.

FLASHING. Structural weatherproofing for joints and angles of buildings, etc., usually sheets of metal or other waterproof material providing ample areas of protection at suitable angles to exclude moisture.

Flashings are employed especially to protect the hips, valleys and eaves of roofs, the joints of roofs with walls against which they abut or with projections such as skylights, chimneys, ventilators, smoke jacks, etc. They are also used about the frames and over the tops of the windows of frame houses. They are especially valuable to prevent leakage due to driving rain, the action of frost, or obstructions in gutters and roof angles caused by accumulations of snow and ice. Desirable features in flashings are durability equal to that of the roofing and elasticity enough to resist expansion and contraction due to changes in temperature, as well as a reasonable amount of shrinkage and settlement. They should be simple in construction and easy to apply without leaving any nail heads unprotected or any broken surfaces or exposed edges where water would be likely to penetrate.

A plain flashing is made of a single wide strip laid to cover a joint as of a valley, and to extend up the slopes on each side under the roofing, which laps over and extends down several inches. This type is usually tacked at the edges or otherwise fastened.

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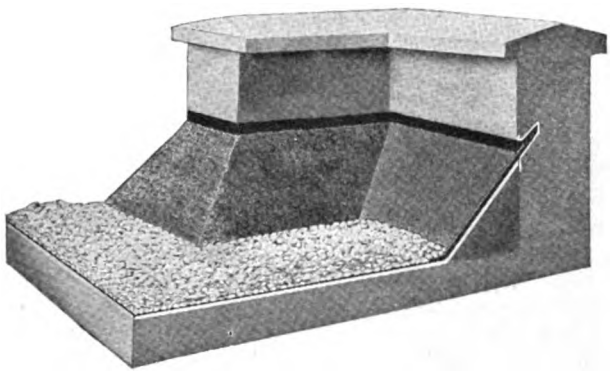
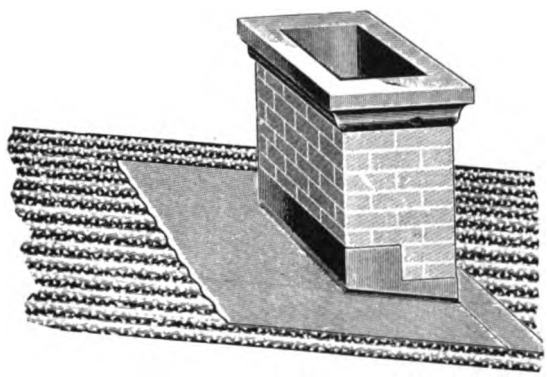
Stepped flashings are made by overlapping small sheets laid like shingles, the upper edges being turned into different horizontal joints of the masonry as in a chimney protruding above a sloping roof, the joints being then pointed, usually with an elastic waterproofing cement, while flat metal hooks driven in the masonry joint are sometimes used to hold the flashing in place.

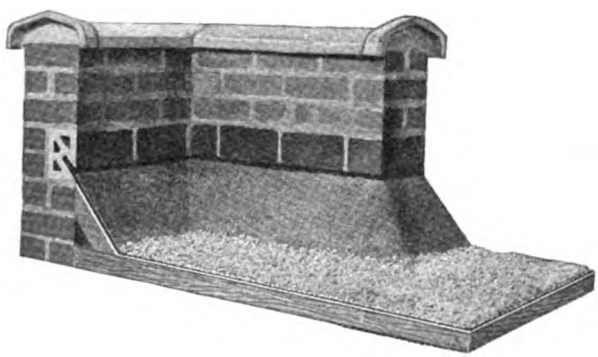
Flashings against stonework are usually driven into prepared grooves which extend diagonally upward to shed rain effectively, rather than horizontally into the wall; or the edge of a sheet lead apron is driven into a horizontal joint above the flashing, the apron being then bent down flat against the wall and overlapping the upper edge of the flashing. Prepared grooves are also used for flashing protection in concrete and tile walls or special courses of grooved blocks are laid in any masonry wall, the flashing extending to the top of the groove where it is secured by suitable pointing. Roof gutters are frequently made with a wide side extension of sheet metal which is inserted under the roofing as a flashing, thus making the gutter a continuation of the eaves. Sheet metal flashings are soldered or overlapped at joints between sheets.



Coping and Diagonal Flashing
The Barrett Company



Chimney Flashing for Corrugated Sheets
The Berger Mfg. Co.

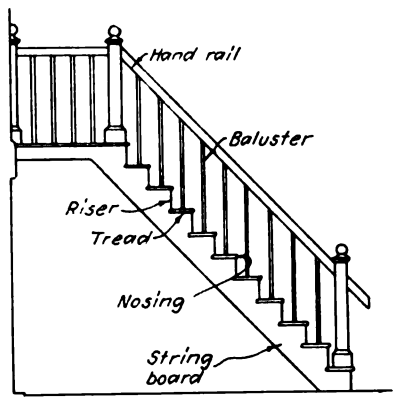


Coping and Flashing Block
The Barrett Company

The sheet metals in common use for flashings include pure iron, galvanized iron, lead, copper, zinc, etc. Ready roofings, built-up roofings and elastic cements are also largely employed in this connection. See Roof. Also Roofing.

FLIGHT (Stairs). A continuous series of steps or stairs forming the part of a stairway extending directly from one floor or landing to another.

Long unbroken flights of stairs are not employed unless necessary to obtain some certain height without too steep risers. Long flights are tiring and a more favored arrangement is to provide a landing with a 90 deg., 180 deg., or some suitable turn. Landings are preferable to winding turns on account of the avoidance of a series of treads converging to one side which limit the efficiency and capacity of winding stairs. See Stair.



Sketch of a Flight of Stairs Showing Parts

FLOATING. A sample spread of plastering first laid on a wall by means of a board called a float to serve as a guide for the thickness of the coat.

FLOOR. That part of a room, building or other structure which forms its lower enclosing surface and upon which one walks; specifically the structure which supports and forms such a surface.

The first requisite for a good floor is a permanent, stable foundation, the simplest foundation being the natural surface of the ground, usually improved by draining, grading, leveling, rolling, etc., especially to form a base for layers of other floor materials. An earth floor or a prepared floor set directly on an earth foundation either at or below the natural surface possesses many advantages, being stable, durable, comparatively unaffected by sound or by changes in temperature and requiring little maintenance. As there is a certain amount of dampness in the earth, the floor is commonly drained and graded above the surrounding ground to offset its tendency to absorb moisture, especially by capillary attraction which makes the floor damp and cold, as there is no air space to permit ventilation.

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The selection of a floor depends on its prospective purpose, on the requirements for resistance to impact if any, on the fire hazard, on the importance of insulation from heat, cold, dampness and sound, and usually on the traffic and the estimated effects of wear on the surface.

The artificial foundations of floors above the ground may be made even more satisfactory and quite as durable as the structure of which they form a part, which is a desirable limit of service life. They are composed of the beams which form a portion of the framework of the building and of secondary beams connecting with the main beams, sometimes having bracing between. Where greater permanency is desired, the wooden floors of buildings, platforms and other structures have been superseded by masonry and metal construction, usually by a framework of steel girders and floor beams with some form of reinforcement to support the body of the floor, which is usually made of concrete, gypsum or the like, either poured in place or consisting of prepared slabs.

Floors of parallel steel I-beams are usual types above ground in fireproof buildings. Low-arched sheet metal forms resting on the lower flanges of the I-beams are frequently inserted to support the body material which is poured on them to a thickness equal to or greater than the I-beam depth, or the spaces above the arches may be filled with hollow terra cotta "arch stone" tiles. Another method is to place a network of rods or cables over the girders or alternately over and under them or to insert some other forming for the purpose. Cinder concrete is frequently used where the concrete is to be covered with a flooring material. The flooring, which may be wood, tiling, bricks, mastic, etc., is usually laid on a prepared surface such as furring strips for wood, a special finishing coat of concrete for mastic, a fresh coat of bituminous liquid for wood blocks, etc. For certain purposes a concrete or gypsum floor is dressed to a smooth surface in lieu of any top flooring, the chief objects of which are to provide wearing surfaces in warehouses, shops, etc., and to afford an agreeable walking surface in dwellings, passenger stations and platforms and wherever the floor is most used by pedestrians.

The all-wood floor is a type frequently retained in buildings otherwise more durable and fire resistant. Wood makes a most desirable floor in many particulars. The material is readily framed and the finished floor may be made suitable for almost any structure by varying the character and application of the materials. A simple all-wood floor is made of a single thickness of boards laid edge to edge at right angles to the parallel joists, to the upper edges of which the boards are nailed; or the joists may be supported on lower beams called binders, to the lower edges of which the ceiling joists of the room below are attached. At intervals in the floor span lines of crossed diagonal struts are frequently supplied to connect and brace adjacent joists, this system of braces being called bridging. The boards forming the floor body may be overlaid with an insulating paper or felt or other fabric on which the flooring is laid, usually at an angle of 90 deg. or sometimes 45 deg., with the lower floor boards. In some cases furring strips are laid on the body boards to receive the flooring, the space thus gained being filled with insulating material. In shops, freight houses, etc., where heavy loads are stored and moved, filled floors with durable wearing surfaces are especially desirable, a common type being a masonry slab laid inside a compactly filled masonry foundation, the slab being supported entirely on the fill and not connected with the foundation or building walls, or columns, and the fill being preferably topped with a 6 in. layer of gravel or cinders.

The advantages to accrue from a filled floor include decreased maintenance and danger from fire and independent settlement of walls and floor if any, as compared with raised wooden floors framed into the building. Filled floors for freight houses are recognized as good practice by the A. R. E. A. and recommended for use even in frame buildings, where wooden sleepers (preferably creosoted) are frequently laid in the top of the fill to receive a single layer or heavy floor plank; or sometimes tonged and grooved flooring is laid over the plank, a similar construction being suitable for any heavy duty floor. When wood blocks are used, either treated or untreated, they are usually laid with their grain perpendicular to that of the supporting boards, the blocks being variously connected together by means of projections and indentations on the edges or separated by projections which afford spaces into which pitch or some similar binder is poured. See Flooring.

FLOOR (First). The floor or story of a building immediately above the basement floor, or at or above the surface of the ground. See Floor.

FLOOR (Ground). See Ground Floor.

FLOORING. The upper layer of material supported on the fill, frame or body of the floor and which presents the finished surface on which one walks.

The principal kinds of flooring include wood flooring boards, wood blocks, hard finished concrete, gypsum, mastic and various kinds of tiles, as pottery,

Mastic Flooring in Locomotive Erecting Shop
The Johns-Manville, Inc.
(See Page 722)

stone and concrete. Floor tiles are manufactured blocks, usually rectangular or sometimes hexagonal, etc. They are usually laid in cement and are sanitary and durable for average pedestrian traffic.

Mastic is an asphaltic flooring mixed and laid in

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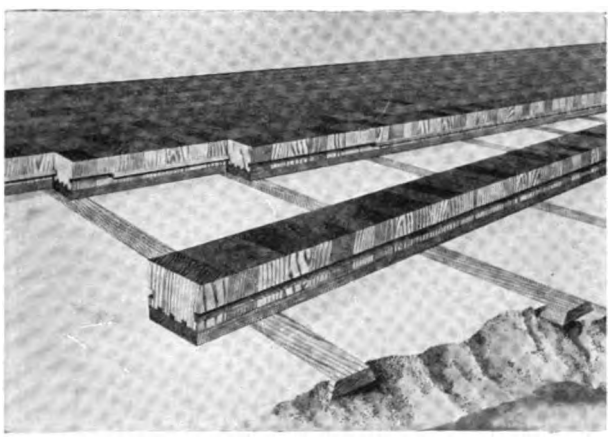
place, sometimes containing gravel or crushed stone according to requirements. It is resilient, fire and waterproof, durable and adaptable to heavy trucking and severe impact. Concrete flooring consists of a top coat of fine concrete rich in cement and sometimes containing a special hardener. It is usually spread on the leaner concrete floor body at least one inch thick and carefully smoothed to a true top surface.

Gypsum flooring is made of a combination of burnt gypsum particles with a small percentage of wood chips. It may be laid like concrete serving as both a body and a top flooring, in which form

Kreolite Wood Blocks
The Jennison-Wright Co.
(See Page 721)

it is fire and waterproof, durable, adapted to severe use and if the reinforcement is suitable the slab will have resilience.

Wood flooring blocks of various kinds and shapes are in use, especially for flooring shops, freight houses, platforms and engine houses. Some are treated with wood preservative which tends to extend the service life, especially where the flooring is subjected to alternate dryness and dampness. These floorings are laid on any good foundation, the blocks usually being formed with grooves or projections or used with strips or some similar fitting devices to hold them in their correct relative positions in the floor. They may be laid on any firm floor body as on concrete, or wooden floor boards. Care is taken to provide spaces between rows of blocks for expansion and to prevent the floor from



Bloxonend Flooring
The Carter Bloxonend Flooring Co.

bulging upward in damp or humid weather. Wooden block floors are preferably made of some wear-resistant wood which is readily penetrated by preservative, such as southern yellow pine, etc.

Hardwood flooring is made of various woods such as oak, yellow pine, hard maple, cypress, fir, etc. It is tongued and grooved lumber dressed on two sides, from 1 in. by 3 in. to 1¼ in. by 6 in. in random lengths, usually 8 ft. to 20 ft. depending on the kind and grade of the timber. Yellow pine flooring 1 in. thick is dressed to $\frac{13}{16}$ in., while the widths are reduced ¾ in. by dressing, a 3 in. wide strip dressing to 2¼ in. wide, etc. Special freight house flooring has tongues and grooves close to the bottom, so that when laid it has a deeper wearing surface than standard flooring. Hardwood flooring is toe-nailed to the floor boards from above the tongue when being laid, and the surface of the completed floor is planed, usually with a special hand or power planer to smooth down any ridges. See Floor.

FLOORING (Hardwood). Flooring of tongued and grooved boards of any suitable timber, 3 in. to 6 in. wide, dressed on both sides and shipped in lengths as ordered plus a small percentage of short lengths. See Flooring.

FLOORING (Mastic). An asphaltic flooring laid in large units in shops, warehouses, freight and engine houses, etc., where resistance to heavy use such as trucking and handling castings, wheels, etc., is desirable. Mastic is resilient, waterproof and durable. See Flooring. Also Floor.

FLOORING (Tile). Flooring consisting of thin blocks of hard burnt pottery or of marble, slate or concrete.

These tiles are usually laid on a fresh surface of wet concrete with cement between the joints and around the edges of the floor. Tile floors are frequently laid about fireplaces in stations, as well as in bathrooms and lavatories. The smooth hard surface is readily washed and notably sanitary. See Flooring. Also Floor.

FLOORING (Wood Block). A floor made of blocks of wood, preferably placed on a solid bed as of concrete and on end; that is, with the grain vertical.

These floors may be made of blocks of any kind of timber, preferably of wood which is durable in compression. The blocks are frequently creosoted, while the floor when successfully laid with proper expansion joints, is very durable and adaptable to heavy shop and freight house floors. See Flooring. Also Floor.

FLUE (Building). A space, a passage or a tube for smoke, heat and gases, usually in a chimney; or a side passage leading from a furnace, stove or fireplace to the main passages in the chimney.

Flues are made of special sections of tiling, usually rectangular, with rounded corners, also of fire brick or other fire resistant material, sometimes of radical shapes for circular flues. Some large chimneys or stacks have horizontal flue openings under ground or at the base of the structure where the draft is created. See Chimney.

FOUNDATION (Building). That part of a building which is below grade or beneath the lowest tier of beams and which supports the structure.

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A building is commonly located with the first or ground floor somewhat above the surface of the surrounding earth for drainage purposes, to afford window space in the basement if any, and to minimize the necessary excavation. The level of this floor may be stipulated by ordinance or fixed on some other account, as by the level of a track to be served. The foundation is the portion below the beams supporting this floor, and includes the footings and their artificial supports, if any, which are located well below the frost line to prevent heaving.

The ordinary footings of a building foundation consist of a slightly wider course of masonry than the main walls which they support, an 18-in. footing commonly supporting a 12-in. wall. Around the outside of the footing course and sometimes also around the inside, a line of drain tile is laid with suitable outlets and with a covering of cinders to lead away water which may find its way down the outside of the foundation wall and any that may accumulate in the space beneath the floor. Where the bearing power of the soil is insufficient, the footings are spread to distribute the loads, or extended down to a more solid stratum or placed on piling driven to firm bottom.

Footings are usually made of concrete or roughly dressed stone masonry, even though the foundation walls may be of some other material such as brick or hollow tile. Concrete footings and the underground portions of foundation walls may be constructed economically of concrete, the material being largely placed by gravity from mixers operated at or above the surface, especially in firm ground where no forming is necessary for the footings. While forms are eliminated in stone masonry or brick foundations, the placing of the blocks necessitates the services of more and higher skilled artisans.

The foundations of most buildings include the construction of masonry cross walls, and masonry footings for columns in the interior of the structure as well as concrete floors, manholes, etc., with provisions for drains, sewage and water pipes, doorways, windows and stairs, all of which are stipulated in the specifications and shown in detail on working drawings which are made a part of the specifications. The outside surfaces of foundations up to the ground line are preferably treated with a coating of waterproofing. The masonry above ground is carefully pointed, or sometimes covered with a coating of stucco. Concrete foundation walls are sometimes lined to resemble stone masonry. The top surfaces of foundations generally are leveled carefully to provide even bearings for the sills or base of the structure.

FRAME. The sustaining skeleton of a building, consisting of members fitted, joined and erected to support the body of the structure.

The frame is composed of main members, principally columns, beams, braces and trusses with such intermediate minor members as are necessary to so reduce the spans of open spaces that the finish may be properly supported. See Building. Also Roof.

FREIGHT HOUSE. A building designed for the handling of freight traffic, consisting essentially of one or more warehouse rooms, an office for the clerical staff and adjacent trucking platforms, all located in proper proximity to special service tracks and driveways, preferably with a stationary crane or derrick for handling heavy articles between cars and trucks.

Freight houses are generally classified as (1) terminal and (2) local freight houses and (3) combination houses. A terminal freight house may be located at a division point or other important point as well as at a railway terminal, the freight terminal and yard being located at the end of a spur line as the only method of reaching a desired location

Frame Freight House with Freight House Crane

in the business district to be served. If the business is heavy, separate houses may be furnished for incoming and outgoing freight. A common arrangement at a terminal station is to have the freight house facilities in buildings at one side of the yard between an outside track and a paved street. The office preferably is placed nearest the end of the yard where it is accessible from the street, or sometimes in the second story over the warehouse (this

Two-Story Brick Freight House

arrangement is not the most convenient) while next to it is the freight warehouse or houses, a continuous freight platform about 8 ft. or more in width and 4 ft. or less above rail top level extending the whole distance between the buildings and the adjacent track.

With this arrangement freight may be transferred from the freight house platform across gang planks through the open doorways of cars standing on the

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Brick Freight House with Offices on Second Floor

parallel tracks, when necessary to sort package freight to load each of a number of cars spotted on two or more tracks to be billed to different destinations.

Freight houses are commonly one story buildings, the warehouses being usually unceiled, but with walls sheathed on the inside to about 8 ft. high for protection against the impact of heavy freight piled in the house. This sheathing also protects sliding warehouse doors, when arranged to slide inside the outer walls. The warehouse floors are about 2 ft. 6 in. to 3 ft. above the driveway used by trucks and about 4 ft. or more above the tracks, the platform on the track side sloping to about 2 in. from the house line to its outer edge.

Spur tracks are sometimes extended through the whole length of the warehouse, terminating at an inside end platform beyond which is the office portion, thus dividing the floor of the warehouse into isolated side portions. Substantial fireproof construction of these buildings is desirable as their contents are valuable and usually include more or less inflamable materials. Outbound freight houses are usually not more than 30 ft. to 40 ft. wide while inbound houses are sometimes 60 ft. wide, greater widths being considered uneconomical. A covered platform annex is frequently used as an extension for handling outgoing freight with a freight crane and a vehicle ramp at the end.

The floor of a freight house, being subjected to constantly changing loads and continual wear from trucking, is designed to carry safely the usual maximum load. As the building is elevated above the adjacent service tracks and the driveway, there is a vacant space below the floor unless it is filled inside the foundation. Many freight houses rest on piles, posts or pillars which support the sills, while others are on masonry foundations. In the first type the floor is commonly of deep-tongued hardwood flooring laid diagonally over heavy floor boards, which rest on the sills and floor joists, or sometimes a single floor of heavy boards usually not less than 2 in. thick. A more permanent floor is obtained by erecting masonry foundation walls after which the inside space is filled with gravel or sand, thoroughly flooded, tamped and rolled and covered with a 6 in. layer of cinders, on which a similar layer of concrete is poured. A top finish of special concrete containing a mineral powder or some other hardener may be employed, or a layer of mastic, or a hardwood floor on furring strips, or a wood block floor set in the concrete with a view to obtaining a permanent hard, smooth-wearing surface suitable for trucking, but with sufficient resiliency to be easy on the feet. Secondary advantages of any such filled floor is comparative freedom from deterioration and from rats and mice.

Brick, concrete or concrete blocks, corrugated iron and wood are the materials used commonly in freight house walls. The cheapest construction is of battened boards, while brick is a much used material for medium and large permanent houses. A horizontal fender timber is required at about the floor level on the driveway side to prevent trucks from scraping and injuring the walls, while a similar

Brick Freight Station with Covered Platform

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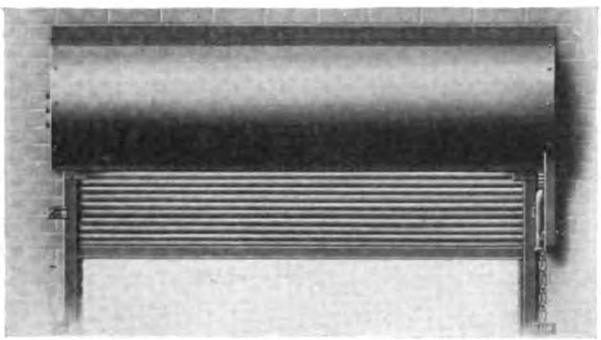
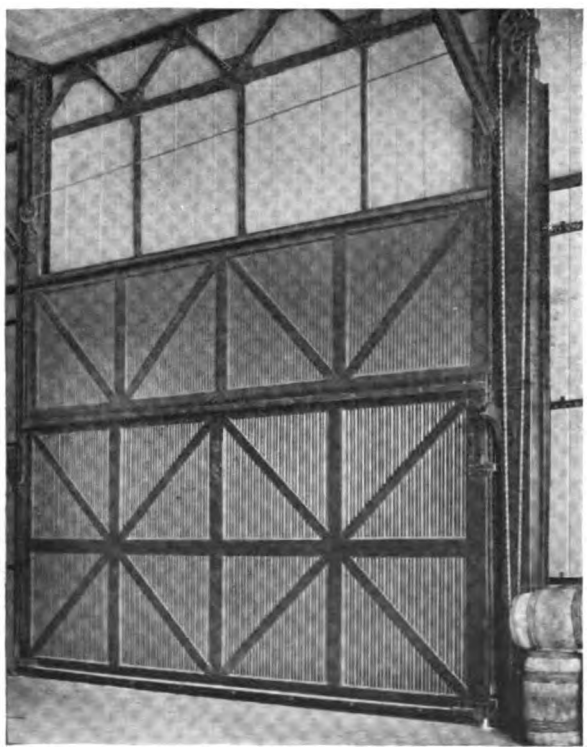
timber on the platform side will help to prevent injury to the wall from heavy barrels, etc., rolled out of cars.

Freight house roofs are usually of rather flat gable types on parallel wood or steel roof trusses resting on the side walls, although some roofs are arched. The roof covering may be any warehouse roofing material suitable for the pitch selected, preferably placed on dressed and matched boards 1½ to 2 in. thick, or an equally solid and water-tight construction.



Rolling Steel Door
The J. G. Wilson Corporation
(See Page 841)

Freight house doors made of metal or wood are usually about 8 ft. or more in width, placed in continuous rows in busy houses or a car length apart where less freight is handled, provided there is a platform between the house and the adjacent track, and hung on overhead or lifting fixtures to conserve space as well as time consumed in operating. They are made in roller lift or upward folding patterns or of the horizontal sliding type. The lifting doors, are used especially where there is not sufficient wall space between to house an open side-slide door, which type is restricted to intermediate wall spaces which will accommodate one or more doors each. By using two or more parallel fixture tracks, the doors may be made to slide horizontally from each side of a wall space or even past a wall space, from doorways on either side. The source of light in a freight warehouse must be higher than the piles of freight and is usually through transom lights above the doors or sometimes a continuous row of transom sash or even higher sash above the doors throughout the length of the warehouse, in addition to skylights or some other form of roof lighting, while electric lighting is also considered a necessity. A dormant scale is provided for weighing package freight, and booths with desks and lights are provided in suitable locations for the accommodation of warehouse clerks.



"Kinnear" Bi-folding Door
The Kinnear Manufacturing Co.

Local freight houses have usually one warehouse for both incoming and outgoing freight, provision being made to keep the two classes piled separately. A common size of local freight house is 24 ft. by 80 ft., with a clearance of 16 ft. in height between the trucking floor and the roof trusses. A local freight station of any importance has usually at least one parallel double-ended siding along the front and the entire length of the platform. This siding is preferably a train length long or longer. Two or more parallel tracks located behind the house complete a convenient layout, the nearest being adjacent to the back platform and the farthest abutting on a parallel driveway. There is usually access by driveway between the tracks to the end of the freight house and the rear side of the front platform.

Many small stations have combination freight and passenger houses, the freight portion being raised about 4 ft. above the track level with inside steps leading up from the ticket office, a warm room and express compartment and a general freight wareroom. The high and low level portions of the platform are connected by a ramp, while the freight house doors 8 ft. wide and one in each side, slide on rollers moving on a metal bar or track mounted overhead.

Smaller wayside stations are usually located alongside the main track. This style of combination building has only three rooms: a general waiting room and a general freight room with a small office between, the platform being at rail level and the package freight handled from trucks.

FREIGHT HOUSE (Inbound). A building for the handling of freight for delivery to consignees. (A. R. E. A.)

Inbound freight houses, where the business justifies their construction, are wider than outbound houses, usually 40 to 60 ft., as it is necessary to provide temporary storage for more of an accumulation of freight awaiting delivery to consignee. A house wider than 60 ft. is not considered economical, the trucking distance being too long. Platforms at track level are required on the receiving side while a paved driveway for trucks and wagons on the delivery side is of suitable height for the decks of vehicles which are preferably protected from the

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weather by an extension of the main roof. See Freight House.

FREIGHT HOUSE (Outbound). A building for the receiving of freight by the railway company for shipment. (A. R. E. A.)

A separate house for outbound freight is always desirable where the business justifies it. The outbound house is usually not more than 30 ft. wide, as great accumulations of freight are not permitted and the trucking distance is minimized by this control of the despatch of goods received for shipment. The doors of outbound freight houses may be spaced "a car apart" so that the doors of a string of coupled cars may be spotted opposite the freight house doors; while at busy stations the doors are more commonly as close together as possible along the entire length of the warehouse. The platform on the track side is usually 8 ft. to 10 ft. wide, and an end platform with a ramp is commonly used for shipment of vehicles. Where the freight house is designed without a platform and placed close to the track, double slide or rolling lift doors are used to accommodate car doors at any point along the side of the building, as it is not feasible to space freight house doors for all lengths of cars. See Freight House.

FOX TAIL WEDGING. A wedge for expanding the split end of a tenon, thereby enlarging and fastening it in a mortise, to increase the firmness of the joint. This device is sometimes employed in joinery instead of the use of nails or glue, where first-class mortise joints are desired.

FURRING. Flat strips of timber secured to joists or rafters as a means of bringing them to a level to form an even surface; or strips fastened to a wall of a building for nailing lath on and to provide an air-space between the wall and plastering.

Floor strips laid in concrete and other solid floors for the purpose of supporting floor boards which are nailed to them are also known as furring strips. See Freight House.

G

GABLE. The vertical triangular upper portion of the end wall of a building from the level of the cornice or eaves up to the apex of the roof. A gable with the cornice extending across the base of the triangle is called a pediment. It is common practice to finish the gable with copings or parapets. See Gable Roof.

GABLE ROOF. A roof which has two opposite and usually equally inclined plane surfaces rising from the eaves and intersecting to form a top ridge or comb. It is the common style of roof for small railway buildings such as section houses, pump houses, tool houses, ice houses, way passenger stations and freight depots because of the simplicity, economy and strength of the frame in wood where the span is within the limits of the lengths of roof timbers commonly carried in stock.

GABLE WINDOW. A window in the gable of a building or a window with a gable top. Gable windows are frequently installed in shop gables, etc., to be used primarily as ventilators.

GAGE (Wood Marking). A carpenter's tool used to strike a line parallel to the edge of a board.

This tool commonly consists of a guide block with a set screw in the edge and a square hole in the middle, through which is passed a small wood or metal slide bar about 8 in. long, one side of which is divided into inches and fractions while a steel pin protrudes slightly from the side of the bar opposite the zero point as a means of marking the surface of a board. The guide block is held flat against the edge of the board, along which it slides as the tool is drawn over the surface.

GAMBREL ROOF. A roof with two opposite sides, the slopes of which are broken by equal obtuse angles, making a secondary ridge parallel with the top ridge part way down each slope. This type of roof is designed to afford the maximum head room under the roof. See Gable Roof.

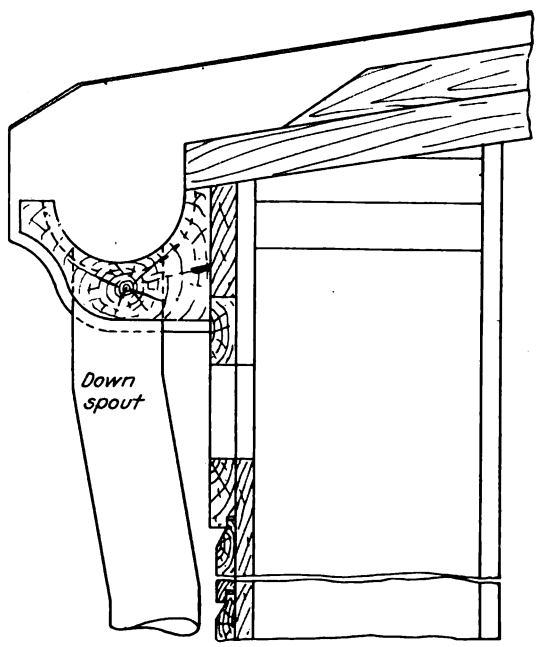
GROUND. A strip of wood nailed to a wall before it is plastered to act as a stop for the plastering around door and window openings.

The surface of the ground is in the plane of the plaster coat which is spread on the wall flush with the stops. Moldings and other finish are fastened over the grounds.

GROUND FLOOR. The floor of a building, on or near the level of the ground and resting on joists which form the ceiling of the basement.

Some buildings with solid foundations have only one floor. The term ground floor is used commonly when a building has more than one story and usually a basement beneath the ground floor. See Foundation (Building).

GUTTER (Building). A trough, usually of metal or wood, built as an extension to or placed below the eaves of a roof to catch and dispose of the moisture from the roofing surface.



Sketch Showing Gutter and Down Spout

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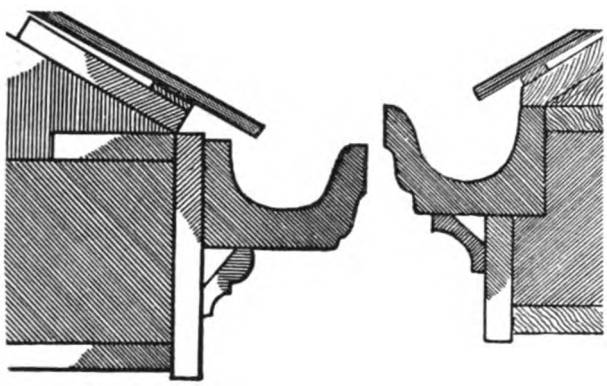
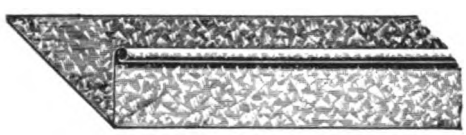
Gutters are made in various forms, as flat bottomed, half-round, half-oval and ogee shaped. Wooden gutters are usually turned, one-piece ogee or sometimes half-round sections. Metal gutter types, some of which have extensions by means of which the section is flashed up into the roof and under the roofing are commonly used, the principal materials being galvanized iron, pure iron, copper, tin, zinc, etc., made in convenient lengths which are soldered end to end in place. While gutters are always placed on sufficient grades to carry water to the down-pipes, the fall must be limited or the gutter will overflow at the down-pipe inlet which should be located at the bottom of the grade so that the water will not run pass it. Accumulations of dirt, leaves, etc., are periodically cleaned from gutters to prevent corrosion and overflow, while recoating with metallic paint is frequently considered an annual necessity, especially where cinders fall on the roof, accumulate in the gutter and tend to corrode the metal.

Station Building Showing Gutters and Down Spouts



O. G. Wood Gutters
E. M. Long & Sons
(See Page 735)



Metal Gutter
Berger & Co.

GUTTER (Roof). A trough placed close beneath or built as an extension to the lower edge of a roof to receive the water which falls on the roof and to lead it by gravity into down-pipes which extend down from the invert of the gutter to the ground or to sewer connections. Roof gutters prevent water from dripping from the eaves with a tendency to seep into foundations and basements, or form ice which damages roofs and may injure persons passing beneath.

Roof gutters are made of wood, pure iron, galvanized iron, tin or other metals. They are often lined with extensions of the roofing. In case snow or debris obstructs the gutter or down-pipe intake, the water will overflow and form ice in cold weather. Frequent inspection and cleaning is advisable to prevent cinders, leaves from trees and other roof debris from obstructing these waterways, and causing overflows.

H

HEAD HOUSE. The portion of a terminal passenger station between the ends of the tracks and the street entrance, provided for the accommodation of persons waiting for trains, and usually containing a terminal platform with a fence separating the tracks from the waiting rooms, lobby and appurtenances.

HEADER (Building). The large beam into which the common joists are framed in openings for stairs, chimneys, etc.

Headers in buildings sometimes span extensive openings, but are usually limited to a distance of 10 ft. to 15 ft. between posts. Longer headers are usually steel beams or girders.

HEEL (Rafter). The end or foot of the rafter which rests upon the wall plate.

The rafter is usually sawed to a bevel to provide a suitable bearing on the wall plate. An extension which is spliced or otherwise secured to the main rafter to support the eaves is known as a jack rafter.

HERRINGBONE. A double diagonal arrangement of brick, tile, wood flooring or other rectangular units.

The herringbone style is sometimes used in laying brick platforms in front of stations and between tracks. Hardwood flooring in the broader widths is also sometimes laid in this form.

HIP. The timber placed on the slope formed by the salient junction of two sloping roof surfaces.

The framing on which these diagonal roof timbers rest is made additionally substantial in order to support the hip rigidly and to maintain the lines of the roof structure.

HIP ROOF. A roof with four inclined surfaces extending from the four sides of a building to a

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common apex or to a comparatively small flat square top. This style is frequently used for square buildings such as dwellings or in combination with the gable style for any building adaptable to gable roof construction.

HOOD MOLD. The molding which projects over the head of an arch above a door or window, whether inside or out; sometimes called dripstone or weather mold.

HOUSE. A structure intended or used for human habitation, especially a fixed dwelling place with its appurtenances; with a qualifying adjective or prefix, a building other than those used for human habitation, as an engine house, store house, tool house, etc. The term as applied to dwellings is usually restricted to structures of some extent, excluding shanty, cabin, cottage, hut, shack, etc. A house may contain one or more rooms. See Building.

I

ICE HANDLING. The supervision of all steps in the disposition of ice from harvesting or receipt to delivery with a view to the prevention of waste and conservation in use.

The proper handling of ice requires intelligent, constant and authoritative supervision over the supply during the entire period of possession. It is estimated that 35 to 40 per cent of the natural ice cut is lost between the ice field and its use on railways, although if properly handled these losses should be reduced to less than 25 per cent. Care in cutting, loading and billing, prompt handling from cars to houses, an attendant to keep ice house doors closed and ice covered, to weigh the ice removed and to deliver it to employees only on presentation of orders signed by a responsible foreman or officer who knows the use to which it is to be put and who has a schedule of reasonable amounts to be requisitioned, is a method adopted on some railways, resulting in saving about 50 per cent of the ice formerly used. Cooling rooms at refreshment stations are frequently not well built, often too large and especially too high. Economy in area of rooms and provision of air spaces between walls tend to conservation at outlying stations. The shipping of ice may be reduced economically to a minimum by local purchases, while contracting for artificial ice has frequently avoided ice famine following mild winters.

ICE HOUSE. A house for the storage and conservation of ice.

The railway type of ice house is not different from commercial plants, except in location, the railway house being placed where it is most convenient for the delivery of ice to cars at the door, or with a minimum of transportation. Ice houses are usually frame structures with double sheathed walls, each sheathing course being preferably protected with building paper or other insulating material while the space between the sheathings may be filled with sawdust, asbestos shavings or some similar material. The floor should be on a filled foundation with adequate drainage, accomplished without the introduction of warm air currents, the outlet pipe being placed below the surface of the water in the drain to exclude the air. The floor is above the surrounding ground and is built to drain toward the central drain. Large ice houses are advantageously divided into rooms which may be unsealed separately to remove the ice.

Ventilation is effected by means of louvers in the roof and by small windows half way between the floor and the eaves, the latter being used after the ice in the upper portion has been removed. Tie rods are frequently used to support the walls against the pressure of the ice inside, these rods being adjusted when the house is empty if there is any bulge in the walls.

In order to handle ice in and out of the house conveniently doors are placed at different levels.

Frame Ice House and Loading Platform

These doors are preferably of double construction to provide an air space, or a single door may lead into an entrance shaft made with loose boards (held between grooves formed by cleats) which may be removed as the level of the ice in the room is lowered. A small elevator is usually set up at the entrance to stock the house and to remove ice as required. The maintenance of ice houses, especially the inside repairs, must be done in the period between emptying and restocking the house, usually in early winter.

INSPECTION PIT. A pit in a track approaching an engine house, designed to facilitate the inspection of engines. (A. R. E. A.) An inspection pit is similar to, but deeper than the engine pits in the house. It usually has steps at each end and is crowned and drained.

At an extensive locomotive terminal the inspection pit is usually supplemented by a cabin or shelter shed for the inspectors with storage space for tools and small parts, such as cotters and brake shoes.

J

JACK RAFTER. Any short rafter which does not extend to the ridge, as in a hip roof, but which usually is spliced to the main rafter and used to support the roofing from the walls to the eaves or to form the roof of an outside entrance or porch. See Rafter.

JAMB. One of two upright members which form the sides of a door frame or window frame, and which support the lintel or other overhead members to sustain the weight of the wall above.

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This term is commonly used to describe the side of a door frame sometimes including the framing timber only but usually the entire structure with the casing.

JAMB SHAFT. An ornamental member of a door or window, frequently placed against or forming part of the jamb. The shaft, usually segmental or semicircular, rests on a base while the tip is surmounted with a capital.

JOINT (Architectural). The surface of contact between two bodies connected or framed together. Timbers are usually joined by means of steel straps and bolts, or by mortises and tenons, while bricks and stones are overlapped and held in place by means of mortar and the weight of the structure above them.

JOIST. Any beam intended primarily to support a raised platform, usually one of the smaller horizontal parallel beams which range from wall to wall in a building to support the floor or the laths or furring strips of the ceiling of a room.

K

KILN DRIED WOOD. Wood seasoned by means of artificial heat or by steam and heat in a room or enclosed space set apart for the purpose. This term is applied to wood from which the moisture is removed by artificial drying, usually with a view to preparing it for early treatment with a chemical preservative. Although the seasoning of the timber is accelerated greatly by this artificial drying, air seasoning is preferred provided there is time to perfect the drying in that manner, as there is a tendency in artificial seasoning to weaken the wood structure when severe pressure of steam is employed. See Wood, Air Seasoned.

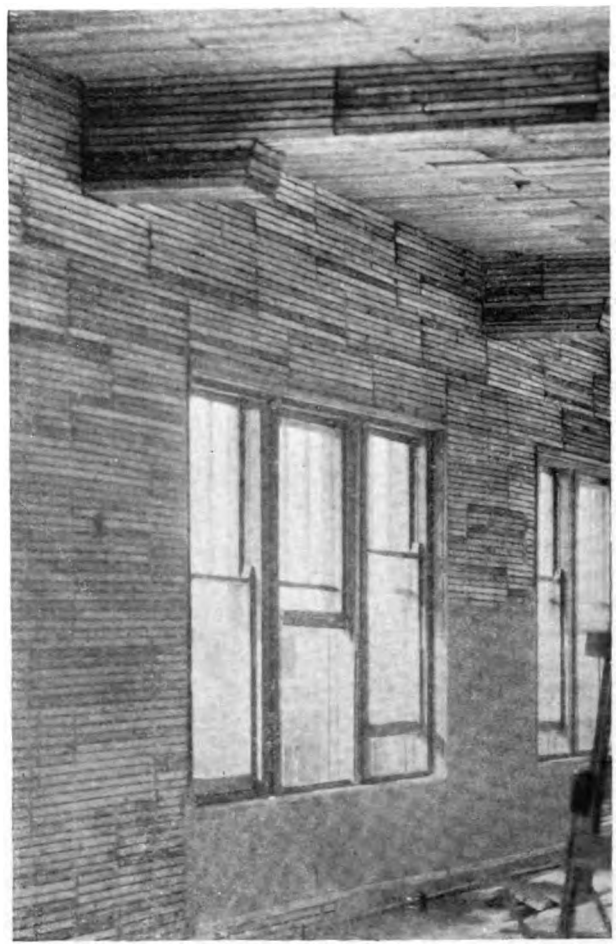
KING BOLT. A rod or a long bolt sometimes used to take the place of a king post.

KING POST. The vertical post connecting the apex of a triangular truss with the base. Commonly king-post trusses are equipped with struts which suport the main rafters and bear upon the enlarged foot of the king-post, which serves as a tie to prevent the sagging of the tie-beam.

KNEE. A piece of timber bent naturally or artificially somewhat in the shape of the human knee, designed as a brace to fit into an angle. Various forest trees, especially those which grow in deep swamps, have roots which form knees.

L

LATH (Wood). A thin, narrow, rough strip of wood designed to cover the studs of a building to support the plastering, etc., or to be nailed to the rafters as a support for the tile or covering. Common lath are ⅜ in. by 1½ in. by 4 ft. long and are sold in bundles of 50 pieces. In nailing them to rafters and studding, they are placed in parallel lines with about ⅜ in. spaces between to receive the soft plaster. When spread over the lathed surface some of the plaster is pressed into the crevices and spreads, forming a key or bond when it sets.



Interior View of Building Showing Wooden Lath and Plastering

LANDING. A level portion of a staircase separating two flights of stairs or an area of floor adjacent to the end of a flight of steps. Landings are frequently designed to avoid winding stairs at turns in staircases, provided the height to be attained is not too great to permit the omission of three or four steps.

LATTICE. Openwork of wood or metal made by crossing laths or other thin strips so as to form a network, as the lattice of a window such as is used in a cellar to provide a passage for air and light.

LAVATORY. A room with conveniences for washing the hands and face, commonly combined with toilet facilities.

LEAN-TO. An extension to a building, with a roof, the rafters of which pitch against and appear to lean against the wall of the main building. This arrangement possesses the advantage of economy in cases where an addition not higher than the eaves of the roof of the main structure is desired. The lean-to roof is sometimes constructed on a flatter pitch than the main roof to gain head room at the low side. The two roofs may be made

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continuous by means of jack rafters or the lean-to roof may abut against the wall of the main building where it is provided with suitable flashings to make the joint water tight. A lean-to is a common form of addition to small dwellings where a one-story kitchen is desirable, as in section houses.

LEDGE. A shelf or a projecting ridge or a molding employed architecturally in trimming a window, or a door.

The top surface of a ledge preferably is sloped away from the building, the outer edge being relatively low enough to shed water. Window ledges are usually made wider than the frame, the ends of the shelf being extended to provide a finish. Door ledges are commonly of masonry, being broader and with less slope than window ledges and forming the entrance step of an outside door, the sill being placed over the joint of the ledge and the flooring.

LEVER (Scale). A steel member used to receive and transfer loads from the weigh bridge to other levers or to the scale beam.

The principal levers of a track scale are the main levers, the extension levers, the transverse extension lever, and the shelf lever. See Scale. Also Scale, Track.

LIGHT, WINDOW. A division or space in a window sash for a single pane of glass. Doors are sometimes provided with sash containing window lights. Large and heavy doors such as engine house doors, are thereby utilized to provide light and at the same time their weight is reduced.

A window light may be one of many in a sash or it may occupy the entire sash. While made in any size it is advantageous to limit the number of sizes of lights used in standard windows in order to economize in the stocks to be carried for replacements. This standardization is particularly desirable in all the sash used in any one building.

LINTEL. The horizontal top member of a frame covering the opening of a door or window, or spanning any other open space in a wall or in a columnar construction, and serving to support a weight from above. See Door Frame.

LIVE RAIL (Scale). One of the two running rails of a track which passes over and bears on the weigh bridge of a track scale, as distinguished from the dead rails which are on fixed foundations.

Some track scales are furnished with live rails only, in which case only cars to be weighed should be allowed to pass over the scale. In case there are dead rails the live rails are gauntleted in the dead rail track, the dead rails being straight and the live rails on the offset line, unless most of the cars passing over the scale are to be weighed. When the scales are located for motion weighing the offset is usually divided. See Dead Rail.

LOBBY. An anteroom between or surrounded by other rooms and used as a passageway or hall of communication, or a waiting room.

A lobby is commonly a central front room entered from the main doorway and does not extend from the front to the rear of the building, but is surrounded on three sides by other rooms. See Station Passenger.

LOOP (Scale). A steel suspension link of a scale used to hold a bearing block for a pivot, suspending a lever in one curved end while the other end is held in a hook to the connecting lever.

LOUVER. A slatted window-frame ventilator commonly used in the gable of a roof. The horizontal slats slope down and outward, overlapping to afford passage for air while excluding rain.

Louvers are used in ventilators on engine house roofs, in the gables of shop roofs, in ice house roofs and sometimes in train shed roofs.

M

MAIN LEVER (Scale). A transverse lever of a track scale suspended in bearings on a base casting or stand secured to a pedestal on the floor of the scale.

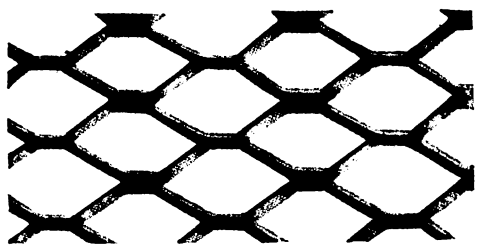
Main levers are arranged in pairs with their load pivots directly beneath the center lines of the weigh bridge girder and the live rail. Each main lever has three pivots, the load, fulcrum and power pivots, the load pivot being the first to receive the load from the bridge, transferring it to the fulcrum pivot whence it goes to the power pivot and is passed thence to the extension lever. See Scale. Also Scale, Track.

MAN-HOLE. An opening from the surface into a sewer, cistern, well, etc., through which a man may pass to clean, repair or inspect the interior.

A man-hole is commonly square or round in cross section. It is preferably furnished with a ladder fixed to a side wall and usually has a cylindrical flanged iron top with an inside cover and a top cover. A ring for removing the top cover is fastened at the side of a depression in which it is countersunk when not lifted for use.

MANTEL. The facing about a fireplace of a chimney, including the mantel shelf above the fireplace, the facings below it and at the sides of the fireplace. Mantels are sometimes placed in passenger station waiting rooms as a finish over fireplaces.

METAL LATH. Lath made of sheets of expanded metal to fill the spaces between wall studs, providing



Metal Lath
The Berger Manufacturing Co.

a stiff steel network which affords a flat rigid working surface with a positive key to hold plaster or stucco. Stiff wire mesh is sometimes used for this purpose.

Some types of metal lath are made of corrugated steel, every second corrugation being left intact to act as solid ribs between the alternate expanded areas of the finished fabric. Advantages of metal

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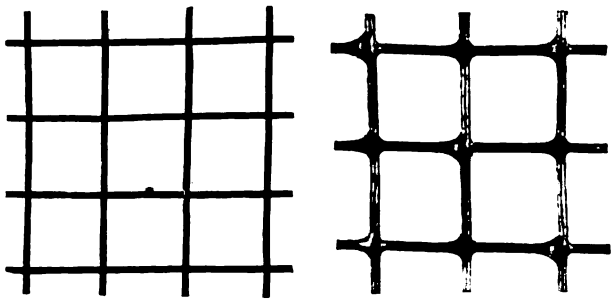

Metal Lath
The Buffalo Wire Works

lath include stiffness that permits wide studding spaces, and regularity in form which saves plaster, as well as resistance to fire and adaptability to quick building. (See Page 680).

MITER. A joint formed by the ends of two pieces, as a molding, each cut off usually at an angle of 45 deg. and matched together to form a right angle. The term is also applied to pieces meeting at any angle and matched together on a line bisecting the angle.

A piece is frequently hand mitered by holding it in a wooden trough (formed of a bottom board and two upright side boards, both of which previously have been sawed through to the level of the bottom at the desired angle) called a miter box and using the saw in the prepared angular saw grooves.

MOLDING. A plain or curved finishing strip having either indented surfaces or projections or a combination of both, sometimes highly ornamented and commonly used for the decoration of cornices, door and window jambs, lintels, etc.

MOTION WEIGHING. The recording of the weights of cars passing over the scales at not more than 4 miles per hour, the car being 3 seconds or longer on the weigh bridge.

Motion weighing is usually practised only in hump or classification yards where the cars are uncoupled and allowed to run down grade over the scales and as far as desired on to the proper tracks below the scales.

MULLION. One of the slender upright bars which divide and hold the panes of glass of a window. A mullion is provided with a narrow flange against which the panes of glass bear and where they are primarily fastened by means of small triangular pieces of tin, one corner of the tin being driven into the mullion while the piece lies flat against the glass, and is subsequently covered with putty.

N

NEWEL POST. The large end post at the bottom of a staircase into which the lower end of the handrail is mortised.

The newel post is more or less ornamental, taller and larger in section than the balusters and is set on the floor or on the bottom step of the staircase. It is commonly a paneled boxed post with an ornamental cap or round column with top and bottom moldings, etc.

NOSE IRON (Scale). A terminal scale lever casting designed to hold the knife edge or pivot bar of an extension lever and to be moved slightly when necessary to lengthen or shorten the lever as a means of adjustment, by loosening, moving and retightening the round bolts which pass through oval holes in the web of the lever. Only the longitudinal extension levers of a scale have nose irons. See Scale.

NOSING, STAIR. The rounded and projecting edge of the tread of a stair step, or the edge of a landing, molding or drip.

A nosing is commonly integral with the tread of a step or landing, but where travel does not touch it, it is usually a half-round finish nailed across the ends of the boards as on the front and sides of a balcony floor or at the balustrade ends of the steps of a stairway.

O

OGEE. A double or reverse curve formed by the union of a convex and a concave line. This term is used in architecture, joinery, etc., to describe moldings, roofs, eave troughs, arches, etc., which have oppositely curved surfaces, the sectional outline of which is a reverse curve. By extension, a double ogee becomes a wave, a double ogee reversed is a brace, etc., these terms being used to describe moldings.

OIL HOUSE. A building used for storing and sometimes for mixing oil used for lighting, lubrication and power.

Oil houses are fireproof structures, usually of masonry or steel or both of these materials, frequently supplemented by large outside storage tanks either elevated or under-ground, and car level platforms for the transfer of oil from cars to tanks, barrels, etc.

Considerations in the location of an oil handling plant are accessibility to the engine house, shops and service tracks, detachment from other buildings and other precautions against fire, good ventilation, provision of a raised portion or bench on which to place containers with faucets high enough to discharge oil into cans.

A one story and basement structure is preferable, the storage compartment being above in order to deliver oil by gravity into the supply tanks below; or pumps and fixtures are installed in the basement for handling the oil from the lower level, to which it is delivered by gravity from the car.

The size of the house depends on the extent of the storage, the number of tanks to be used and the arrangements for the receipt and delivery of oil. Lamp rooms and waste storage rooms are sometimes provided in the oil house, the partitions between rooms being substantial masonry walls. Stair cases, window frames, sash and doors are fire proof, while metal window shutters are frequently provided. Artificial lighting is electrical, no open lamps being permitted. The interior temperature is usually maintained at about 60 deg. F. by steam heat from pipes or radiators attached to the outside walls.

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P

PANE. A small square or panel of window glass filling one opening in a sash.

There may be from one or several to many panes of glass in a sash, depending on the dimensions of the sash and the panes, and on the relative strength of the mullions which support the glass. Stock sizes of window panes range in even numbers as 8 in. by 10 in. and 10 in. by 12 in. when of ordinary glass. Plate glass is cut to any size. An advantage in standard window designs is the standardizing of window pane sizes and the minimizing of the number of sizes which it is necessary to carry in stock for the maintenance of structures.

PANEL (Building). A thin rectangular sheet of material, usually of wood framed within four thicker pieces such as the panel of a door or the ranges of sunken compartments in wainscoting, cornices, ceilings, etc.

Panels are frequently covered with veneer, a thin layer of finishing wood cut from about the circumference of a log, and steamed to lie flat.

PARAPET. A dwarf wall along the edge of a roof, or around a terrace walk, etc., designed to give height and finish to the wall, to hide the edge of a sloping roof and sometimes to prevent persons from falling over.

Parapets may be plain, perforated or paneled. A plain parapet is a simple wall with a coping at the top and a corbel table below while the perforated type is pierced with various designs so that light may pass through the openings, while a paneled parapet is divided into a series of panels, either oblong or square and more or less ornamented but not perforated. See Coping.

PARTY WALL. A wall between two buildings which is common to both, or one built across a single building to divide it for separate occupancies.

A party wall is preferably insulated to deaden sound and frequently utilized as a fire wall. See Fire Wall. Also Fire Door.

PASSENGER SHELTER. A shed with one open side toward the track, designed to protect waiting passengers from the weather.

Passenger shelters are usually wooden structures, without lath, plaster or inside finish. They are sometimes built as twin shelters with fences, high level platforms and a connecting overhead bridge to serve double or multiple track lines. See Station, Passenger.

PASSENGER TERMINAL. A station at the end of a railway, usually an extensive building with facilities for the interchange and transfer of passengers baggage, mail and express, especially where the terminal is used by more than one railway or by diverging divisions and branches of one system.

It usually consists of a head house and train sheds, the former containing all facilities except the covered tracks and platforms within the shed which usually extends from the middle of the rear of the head house like the stem of a letter T. See Station, Passenger.

PEDESTAL. The base or foot of a column; the part on which the upright work stands.

It consists of a plinth for a base, the die or dado and the cornice or surbase molding. When the height and width are equal it is called a square pedestal; or it is termed double or continuous according as it supports two or more columns without a break.

PILASTER. A rectangular pillar furnished with a capitol, a base, etc., corresponding to a column and set in a wall to increase the bearing area.

Pilasters are frequently attached to a wall behind the columns, or along the side of a building, seldom projecting more than one-fourth of their breadths.

PITCH, COAL TAR. A lustrous black, viscous residue obtained in distilling coal tar, consisting chiefly of a mixture of hydrocarbons and extensively used as the weatherproofing and cementing material in roofing and paving.

PITCH, ROOF. The inclination or slope of a roof, expressed as the ratio of the height to the span, as ½ pitch; or of inches to the foot, as 2-in. to 1-ft. pitch; or by degrees, as 30 deg. pitch.

PITCH, SCREW. The advance made by the thread in one complete revolution, usually expressed by the number of threads in one inch.

PITCHING PIECE. A horizontal timber, one end of which is wedged into the wall at the top of a flight of stairs as a means of supporting the upper end of the rough strings.

PIVOT, KNIFE EDGE. A sharp edged bar used as a contact device for a suspended lever of a scale.

The knife edge pivot is commonly a straight bar of special steel, of the same cross section throughout its length, always having a suitable sharp contact edge. It is usually five-sided, being made by beveling both sides of a flat bar equally at angles of about 45 deg. to form the sharp edge; although the cross section may be "pear shaped" or "top shaped" and sometimes diamond shaped or triangular.

The sensibility of the scale depends largely on the maintenance condition of the knife edges and their bearings, which are more readily damaged by corrosion than by wear. The usual rust preventive is cup grease which is recommended by the National Bureau of Standards and which is applied as follows:

Care is first faken that the knife edge pivot is driven up tight, and that it is clean and dry, after which the grease is packed neatly about the knife edge and bearing, being kept away from the crevices where the pivot enters the lever to prevent it from working loose. If the grease tends to loosen the knife edge, the seat may be painted with litharge and glycerine or some similar mixture which will harden in the crevices after which the knife edge is driven up, cleaned and greased as before. Where scales receive daily attention, oiling with a swab or brush is effective if done thoroughly, properly and not less than two or three times a week. Additional means of preventing corrosion are ventilation and drainage of the scale pit. See Scale. Also Scale Pit Ventilation. Also Scale Pit Drainage.

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PLASTER. A composition of lime, hair and sand, usually with a fibrous binder such as hair well mixed with water to form a paste which is used to coat and finish the walls and partitions in a house.

Prepared patent plaster, mixed in proper proportions, is frequently used where expert plasterers are not available or where mixing is undesirable.

PLASTER BOARD. A substitute for lath as a wall covering, consisting of alternate thicknesses of tough coarse paper and thin layers of plaster, the whole board being about ⅜ in. to ½ in. thick, with three layers of plaster and outside surfaces of paper.

Plaster board is secured to the studding by means of flat headed nails, spaces ¼ in. wide being left between the square sheets to allow for expansion. The wall plaster is spread directly on the paper surface of the plaster board which has the advantage of being an insulating material which can be quickly and readily applied. Care is taken to avoid inequalities in the surface of the finished wall over the cracks between the sheets of plaster board.

PLATE. A horizontal timber laid on a wall or supported on posts or corbels to carry the trusses of a roof or the rafters directly, sometimes called a wall plate or a roof plate.

The plate is usually laid flat to entirely cover the ends of the uprights which support it and to each of which it is fastened. See Wall Plate.

PLATFORM. A horizontal and generally flat surface, designed as an approach to trains, and stations or other buildings.

Freight platforms are preferably at car floor level, a little less than 4 ft. above the tops of the rails of the adjacent parallel tracks. Passenger platforms are commonly at or a few inches above rail top level, except at extensive passenger stations where dense suburban or other traffic is handled. Platforms are made of any suitable building materials, such as timber, brick, concrete, etc. Many wayside station platforms are made of cinders or crushed stone with timber or concrete coping. Suitable ramps are provided at the ends or at other points where traffic passes, in preference to steps, although the latter are usually necessary in connection with platforms leading to other levels. Subways or overhead foot bridges are utilized in many cases as means of communication between platforms on opposite sides of parallel tracks as on double or multiple track lines.

PLINTH. The projecting base or water table of a wall, generally placed at the level of the first floor of a building.

The front face is vertical, while the top edge is usually beveled from the wall downward to shed water.

PLUMB. To adjust by means of a plumb line in order to make sure that an upright structure is truly perpendicular, as a wall, post, chimney, or weigh scale rod.

A structure built even a little out of plumb tends to become unstable with age, while a scale will not weigh correctly nor will a machine often run true if the moving parts which should be vertical are out of plumb.

PLY. A layer, usually one of two or more thicknesses of material such as ready roofing, commonly referred to as three ply, four ply, etc. The several layers of roofing are usually united into a single board or sheet by means of a bituminous binder designed to make it impervious to rain, snow, etc.

POISE (Scale). A sliding metal block or weight fixed to the beam of a scale with conical or ball bearings to indicate weights by marking the graduation at which it rests when the beam assumes a true horizontal position with its tip midway between the vertical limits of the trig loop. See Scale Beam.

POST. An upright piece of timber, metal or other material used to support a corner of a building, etc.

Posts may be plumbed or battered according to their purposes in the structure. They are columns and are used in compression.

POWER HOUSE. A building for housing apparatus for generating light, heat or power for various purposes. (A. R. E. A.)

Power houses are usually connected with or contain engine rooms, the apparatus and its housing depending on the kind of power generated.

PRIMING. The first coat of paint applied to any surface with a view to filling up the pores and compensating the roughness or slight inequalities so that when the finishing coats are applied the surface will present a smooth, unblemished appearance.

The priming coat is applied to wood surfaces also to preserve them and to prevent sun checks. All framed work such as door frames, window sash, etc., should be filled and primed at the mill, to prevent checks. See Paint.

PUDDLE. A method of settling loose dirt around a newly graded building or within the foundation enclosure by soaking it thoroughly with water so as to render it firm and solid to form a base for a floor or to present a contour in conformity with the surrounding surfaces.

PUGGING. An insulating composition, usually a coarse kind of mortar, laid under the boards of a floor or on partition walls to prevent the transmission of sound; sometimes referred to as deadening or deafening.

PURLIN. A secondary member of a roof frame designed to rest horizontally upon the main rafters of the truss to support the roof covering or to support common rafters on which the covering is placed.

In steel structures the truss spans of which are not greater than 8 ft. to 10 ft., it is common practice to use angle purlins, while Z-bars, channels and I-beams are used for greater spans. When the distance between purlins is 15 ft. or more, small steel brace rods are generally placed on the lower side to prevent them from sagging in the plane of the roof. When the roof covering is placed directly on steel purlins it is commonly held in place by means of nailing blocks bolted to the purlins. In frame structures the wood purlins are secured to the rafters by means of purlin connections or spikes, bolts, etc. See Purlin Connection.

PURLIN CONNECTION. A wood or metal brace designed to be fastened to the top or side of the truss rafters to hold a purlin in place.

In frame structures the purlin is sometimes held by triangular wood blocks spiked to the top surfaces

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of the rafters or by wood bearing blocks bolted to the sides, and dapped to receive the purlin. Steel stirrups hung from the tops of the rafters provide another means of connecting the purlin to the truss while steel angles bolted to the sides of the rafters and purlins are sometimes used. In steel structures a common purlin connection consists of a steel angle clip riveted to the truss rafters as well as to the purlins. See Purlin.

PUTTY. A kind of cement or paste compounded of whiting or soft carbonate of lime and linseed-oil, mixed to the consistency of dough. In this state it is commonly applied by glaziers for fixing the panes of glass in window sashes while house-painters use it to fill nail holes and other cavities in woodwork before applying paint. Putty is grayish pink in color, plastic when fresh but drying when exposed. If unused putty crumbles, it may be made plastic by adding oil. If painted before it is well set, the oil in the putty will tend to show through or the paint may crack and chip off.

PUTTY IN PLASTERING. Lump lime slaked with water to the consistency of cream and then left to harden by evaporation until it becomes like soft putty. It is then mixed with plaster of Paris, or sand, for the finishing coat. See Plaster.

Q

QUEEN TRUSS. A truss framed with two vertical tie-posts, as distinguished from a king-post truss which has but one tie-post. The upright ties are called queen-posts.

R

RAFTER. A beam that extends from the plate of a building to or towards the ridge of the roof frame and serves to support and give slope to the covering.

In addition to the common or main rafter there are various other special types named after their uses and positions in the roof structure, as for example, the hip and valley rafters. The dimensions of these members vary greatly according to the character and extent of the roof. Extensive roofs have sometimes intricate roof frames made of series of main and several subsidiary types of rafters.

Rafters are usually placed on edge, and equally spaced in parallel rows in one plane, being framed at the top to fit against the vertical side of a horizontal ridge and at the bottom to rest flat on the horizontal plate. See Jack Rafter.

RAFTER, VALLEY. One of the rafters which are disposed in the internal angle of a roof to form the valleys.

Valley rafters are used in all styles of gable roofs where the building is other than rectangular.

RAIL, BUILDING. A horizontal member in a piece of framing or paneling as in a panel door sash or any paneled work, between which are the panels, while the vertical pieces are called stiles; also a piece of timber or metal extending from one post to another as in fences, balustrades, staircases, etc. The rail is mortised to fit into a tenon of the style or into posts which support it. See Stile.

RAMP. An inclined plane affording communication between a higher and lower level, as from the ground to a raised platform, or from one floor level to another in extensive passenger stations where they take the place of stairways if space permits, eliminating the hazards of stairs where traffic is heavy.

Ramps provide means for easy access to raised platforms, especially for vehicles and animals. They are also used in entrances to stock pens where they are fenced and extend from the ground to the car floor level where a removable barrier is installed to control the movements of stock. See Station. Also Platform. Also Stock Pen.

RANDOM WORK. The fitting together of stones in a wall without any attempt to lay them in courses, or the laying of strips of flooring of various lengths to cover the floor space of a room.

Random work is not the highest but may be a very good class of masonry. In practice, hard wood flooring also is usually laid in random lengths, the range of piece lengths being specified by classes of material.

RANGE WORK. The laying of stones in a wall in horizontal courses, all stones in a course being cut to one height.

A stone masonry wall is preferably laid in courses diminishing in height from the base of the structure upward.

REST HOUSE. A building for the accommodation of employees, and containing rest and recreation rooms usually sleeping quarters, lunch room, lockers, baths, etc. (A. R. E. A.)

Rest houses are placed at terminals and division points for trainmen, enginemen and others whose duties require them to "lay over" at these points where their runs terminate.

RETURN. The horizontal end finish to the cornice of the gable end of a roof, forming a shelf beneath the overhang at the lower corner from the eaves trough inward.

A gable and return is proportioned to the width of the overhang and is supported on brackets.

RIDGE. The topmost part of the roof of a building, specifically the apex line formed by the meeting of the opposite rafters at the ridge pole. See Roof.

RIDGE POLE. The horizontal board or timber at the apex of a roof against the sides of which the upper ends of the rafters abut; and to which they are secured to form the ridge of the roof. See Roof. Also Ridge.

RISER. The vertical front board of a step in a stairway, whether the step be in one piece as a block of masonry or built up as in wood. In the first case the riser is the vertical surface, while in the latter it is a board, a plate of metal or a similar thin piece which is set upright under the front edge of the tread above and at the back edge of the tread beneath it.

RIVET, CLINCH. A special rivet or nail made of wire, designed to be clinched around the edge of an angle iron or channel and commonly used for fastening steel sheeting to purlins or girts of buildings.

ROOF. The top cover of a building, shed or platform, erected to exclude the weather. The roof is considered as including the roofing, the insulating

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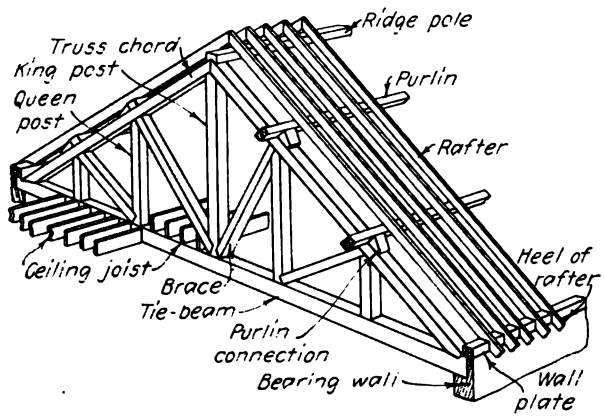

Diagram of a Roof Truss, Showing Parts

material and the roof boards if any, and the supporting framework.

The forms of roofs in common use for railway buildings are the flat, shed (lean-to), gable, hip and sawtooth roofs and various combinations of two or more of these types. Arch roofs and roofs with smoke openings or channels above the tracks are commonly employed in train sheds. Roofs over platforms and adjacent to buildings are usually extensions of building roof over-hangs or eaves, or they are shed roofs hung or bracketed to the building walls, while roofs of platforms not adjacent to buildings are usually of the gable, butterfly or umbrella types with center or side supports.

Recent developments in railway roofs have been along the lines of simplicity and permanence. The simplest roof structure is usually the strongest. Many roof and roofing troubles are traceable to settlement which twists the frame and opens seams. The roof frame should be ample to bear its loads and solidly built and anchored. The trusses should be so spaced and the roof boards of such a grade that the roofing will lay on smooth, solid surfaces. Weatherproof paper should be laid between the roofing and the boards.

The choice of roofing materials is usually governed by the design of the roof. Roofs are made with steep slopes in order to shed water before it can

Flat Tar and Gravel Roof

leak through. Small lapped roofing units, such as slate, tile and shingles are adaptable to roofs of steep pitch, while flat or nearly flat roofs are usually covered with roofing which has no unsealed joints, such as tin, built-up pitch and gravel, gypsum slab and concrete slab roofs. Where roofing which depends on unsealed joints for waterproofing, is laid on a roof of low pitch there is a tendency for high winds to drive rain under the edges of the shingles or sheets; and ice forming under the edges lifts and sometimes cracks the roofing. On the other hand the renewal of a few shingles or tile is usually not so serious a matter as the repair of leaks in roofs laid in larger units.

Although the first requisite of a roof is to shed water, its various uses and the suitability of materials for the structure depend on the location and purpose as well as the form of the building. On account of the danger from sparks and damage from sulphurous fumes and steam from locomotives the best railway practice favors roofs that are weather proof and fire proof, that afford good ventilation and light; and for engine houses, shops and train sheds, roofs that are fire retardent and acid proof within.

Roof design contemplates the use of such materials as will best reconcile the diverse outside and inside conditions which affect the central area above the heated building and the exterior over-hanging eaves. A roof may be required which will resist the weather from without, the fumes and condensing

Hip Roof with Tile Shingles, Bay Window and Gable Roof

steam from within and the effects of heavy ice forming on the eaves from snow water running off the warmer central portion of the roof. The roof frame is usually composed of trusses, or of trusses and girders of wood, metal or protected metal, and usually bears on the upright columns and walls of the building. A succession of parallel trusses is a common form of frame. To these trusses purlins are fastened which in turn support the roof boards, if any, and the roofing.

Close under the eaves or lower edges of the overhang of a roof, wood or metal eaves troughs or gutters are placed to receive the water which falls on the roof and to conduct it to the downspouts.

The details which most directly affect the service life or roofs in general are the solidity of the structure on which the roof is framed; the strength of the roof frame; the care with which joints are made in angles and valleys and around roof openings, such as skylights, chimneys and fire walls, and the flashings at such places; and the waterproofing qualities of the covering.

ROOF BOARD. A board laid between the roof frame and the roofing to stiffen the structure and afford a plane smooth surface on which small roofing units such as slate, tile or shingles may be fastened.

ROOF, BUTTERFLY. A platform roof of opposite, equal upwardly inclined surfaces or wings, one on each side of the center line of the roof. The outer edge of each wing is raised above the center line to drain the water to the center, where it de-

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scends usually through hollow supportinig center columns. This style of roof is favored for passenger platforms between tracks where draining to the center is not impracticable on account of frost.

ROOF, FLAT. A roof laid horizontally or with a pitch of not more than 1 in. to 1 ft. Flat roofs are favored for railway engine houses because of the purpose, shape and extent of the structures, which are such that steep-pitched roofs are usually impracticable and unnecessary. Built-up pitch and gravel roofing is largely used because it is weather proof on flat roofs, is comparatively long lived, does not absorb moisture, and will bear rough usage.

ROOF FRAME. The fabricated skeleton of a roof which supports the roof structure, usually a system of connected trusses, girders, etc.

ROOF, SAWTOOTH. A multiple cross gable roof resembling in profile the teeth of a saw.

The front plane of each gable is nearly vertical, largely of glass and usually faces the north, away from the sun. The rear plane slopes back sharply and is covered with roofing. The sawtooth style is essentially a shop roof, designed primarily to permit of top lighting, because side lighting is not sufficient in side buildings with many machines.

ROOF, UMBRELLA. A platform roof arched or umbrella shaped in cross section and supported on a line of center columns by means of braces. The umbrella roof is used over passenger platforms between tracks and sometimes over freight transfer platforms similarly situated. Platform gable roofs with center supports are sometimes also called umbrella roofs.

ROOFING. The covering placed on the body of a roof to make the structure weather proof.

Roofing is made of many materials and in various forms, the small unit types being called roofing tiles and shingles, while the larger units are known as sheet roofing. A roofing composed of several thicknesses of lapped sheets mopped with a bituminous binder while it is being laid, is called a built-up roofing as distinguished from prepared sheet roofings composed of materials of a similar character and known as ready roofing. Wooden roofing is made of shingles, while metal roofings may be of shingles

Applying Mineral Rubber Asphaltic Roofing
The Standard Asphalt & Refining Co.

or in sheets, as are concrete roofings and those made of asbestos and cement, or of gypsum and wood chips, etc.

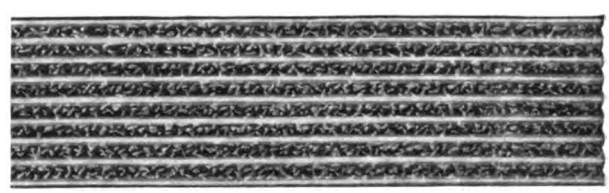
The selection of roofing presupposes a roof structure of suitable stiffness and durability. Probably most roofing failures result primarily from a poor roof or poor workmanship in applying the roofing and flashings. A first consideration is the pitch of the roof and other features of design. Unsealed roofing joints are better suited to steep pitched roofs where the run off is rapid than to the so called flat

Corrugated Steel Roofing
The H. H. Robertson Co.

roofs where the pitch is 1 in. in 12 or less. The large unit roofings and those with sealed joints, such as the built-up, the soldered metal and the large sheet types are more largely used on the flat roofs.

Mansard Sheet Steel Roofing
The H. H. Robertson Co.

The roofing materials in general use are divided by the A. R. E. A. into (1) bituminous substances applied with felts, (2) clay and cement products and slate and (3) metals. The bituminous roofings are (a) coal tar pitch, (b) asphalts, (c) petroleum products and (d) animal and vegetable residues. The



Corrugated Armco Ingot Iron Sheet Iron Roofing
The American Rolling Mills
(See Page 638)

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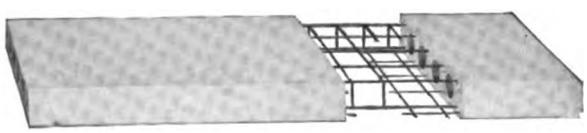
desirable characteristics peculiar to these materials are described as elasticity, practical insolubility in water, adhesiveness and comparative stability. They are used in various mixtures and combinations as saturants for shingle and sheet roofings, etc.

Built-up roofing is favored especially for flat roofs, and is commonly protected by a thick sprinkling of gravel, applied while the pitch is soft, or if the expense is warranted flat tiles or brick furnish superior protection. An advantage of built-up roofs is that they may be made as thick as desired. A well made

Ambler Asbestos Corrugated Roofing
The Keasbey & Mattison Co.

flat built-up roof should have a life of 15 to 20 years.

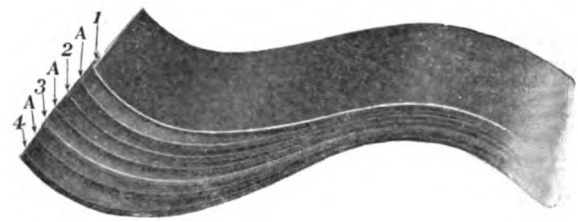
Ready roofing, being more suitable for steeper slopes than for flat roofs is usually applied by unrolling the sheets lengthwise of the roof, starting at the eaves, and laying overlapping sheets upward to the ridge, care being taken to avoid unprotected nail holes, creases, etc. The value of ready roofing increases in ratio with the pitch of the roof. Expan-



Gypsum Roof Tile
The U. S. Gypsum Co.

sion and contraction being important, the ready roofing preferably should be laid during periods of even temperature. The heavier varieties have relatively longer life and are more fire resistant. Stiff ready roofing shingles are largely used on steep roofs, many varieties having protective coverings of stone dust, etc. When laid shinglewise on suitable surfaces they are effective and pleasing in appearance.

Flat slate tiles make a tight roof for steep slopes, provided the roof structure is suitable for the weight of tiles of proper thickness to avoid breakage. Clay tiles are usually made to interlock and although they do not lay as closely as slate, they make a good roofing on steep slopes. The A. R. E. A. recommends slate and clay tiles on roofs of 6 in. to 8 in. pitch to the foot, where expense is not a governing feature. Wooden shingles are not recommended on account of the fire hazard, but asbestos-cement shingles, possessinig elasticity and being fire proof are more favored for railway structures. Asbestos sheet roofing, usually corrugated is made of alternate layers of asphalt cement and asbestos felt enclosing a central sheet of punched metal, the edges



Built Up Asbestos Roofing
Johns-Manville, Inc.
(See Page 722)

of which are protected from the weather. This roofing is fire, smoke and acid resisting, being used for ware-houses, power houses, shops, etc. Large reinforced concrete tile, known as cement tile, laid directly on the purlins, eliminate the necessity for sheathing, reducing the fire hazard and permitting glass to be laid in them, thus avoiding the necessity for skylights. They are in use in many shops and freight houses. Roofings of metallic shingles have been largely used on dwellings and other steep sloped roofs for many years and are especially durable when galvanized after manufacture. Pure iron is of undoubted value as a roofing, in shingles or in sheets, plain galvanized and corrugated.

Stress is laid by the A. R. E. A. on the importance of thorough workmanship in roofs, roofings, flashings and gutters, on the systematic inspection and maintenance as well as in construction. Saving in first cost at the expense of excellence of construction is usually over-balanced by direct and indirect costs of roofing maintenance. See Roof. (See Page 717).

ROOFING, BUILT-UP. A roofing constructed during application, the materials being layers of prepared felt saturated with compounds of oils and asphalts, which are successively laid and mopped with pitch until the required total thickness is obtained when a surface of pitch and gravel or other protective covering is added. See Roof. Also Roofing.

ROOFING, FELT. A fabric made of shredded and ground rags, jute, or fibre asbestos with a binder and used in the manufacture of ready roofing and built-up roofing. See Roofing.

ROOFING, GYPSUM. A roofing made of calcined gypsum and a small percentage of wood chips. This mixture is commonly applied as a concrete to form slabs between steel roof beams. See Roof. Also Roofing.

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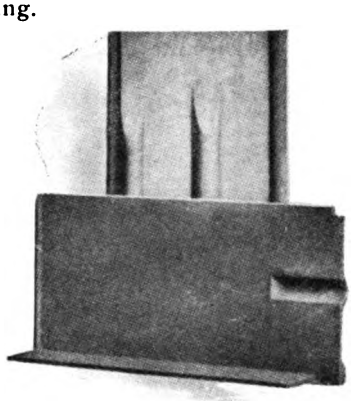
ROOFING, METAL SHINGLE. Roofing made of shingle size sheets of metal, usually stamped with some slight convexity to afford a protected air space beneath the covering. A metal shingle may be of pure iron, tin, copper, zinc, etc. Galvanizing after manufacture is desirable if the shingle metal is not rust resistant. See Roofing. Also Roof.

ROOFING, READY. Roofing made of bituminious substances and felts composed of asbestos, jute or rags in alternate layers of binder and saturated felt. Ready roofing is commonly made in strips 32 in. wide 1 to 4 ply thicknesses and then cut and made into rolls of 108 sq. ft.. or more, each package usually containing enough nails, etc., to apply it. See Roof. Also Roofing. (See Page 734).

ROOFING, SHEET, CORRUGATED. A roofing made of overlapped sheets of corrugated iron or asbestos, secured to the roof, usually by means of galvanized screws with washers, clips or other devices, the joints and screw holes being cemented as well as covered by the overlapping sheet. See Roof. Also Roofing.



Bonanza Tile
The American Cement Tile Mfg. Co.
(See Page 632)

ROOFING TILE, CEMENT. A thin rectangular slab of concrete designed for overlapping and interlocking in such a manner as to form a roofing impervious to the weather.

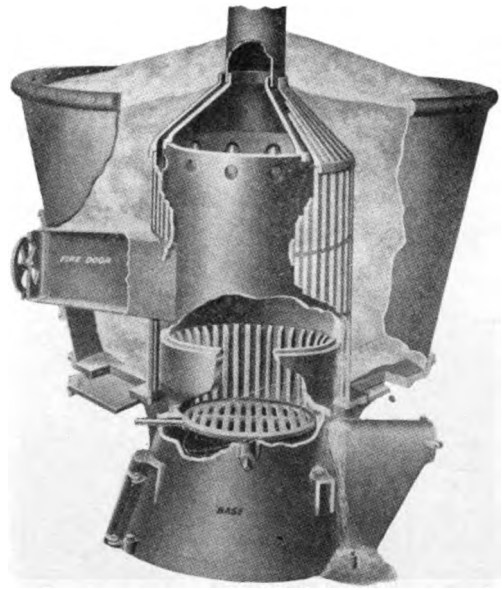
Cement roofing tile used on railway buildings is commonly flat or slightly curved in section, varying in size from that of an ordinary shingle to a slab about 24 in. in width and 4½ ft. in length. The larger tile is reinforced and laid on the roof purlins, while the smaller variety is placed on the roof boards. Both types of tile are sometimes colored to give a pleasing effect. See Roof, Also Roofing.

ROUGH CAST. A plaster resembling fine concrete and made with strong lime mortar and sand mixed with gravel or small sharp stones, and used for facing the exterior surfaces of rough walls or the sides of buildings to give a finished appearance.

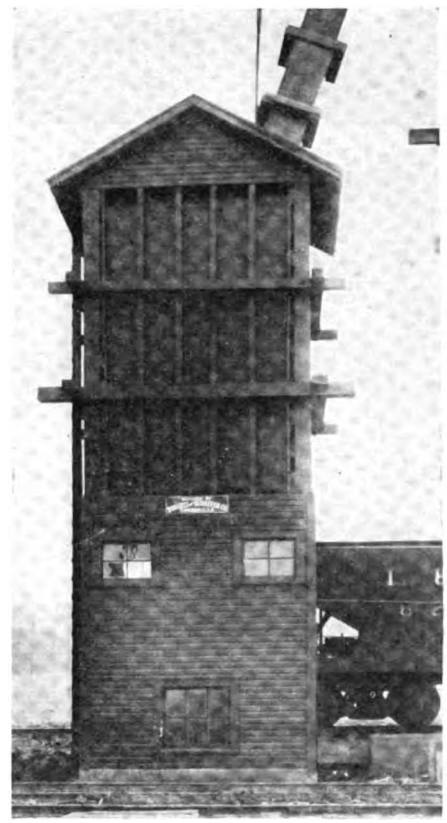
S

SAND HOUSE. A structure used to store and dry sand for use in locomotives.

The sand used in front of locomotive wheels to prevent them from slipping must be fine and dry in order to run freely through the pipes leading from the locomotive sand box to the rails. Artificial drying is necessary to counteract absorption of moisture from the air, even in storage. Sand drying and storing plants are therefore provided at engine terminals and at many outlying coaling stations where the sand can be transferred direct from the drier to the locomotive.



Viloco Automatic Sand Dryer
Harry Vissering & Co.
(See Page 831)



Frame Sand House
The Roberts & Schaefer Co.
(See Page 796)

Sand plants are designed with a view to economy in fuel and material handling. A wet sand storage room, a drying room with a heater and a dry sand bin are the usual requirements. The sand may be

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dried to some extent in storage by ventilating the building, preferably with louvers and roof ventilators, but the final drying is done by means of special sand drying stoves or by coils of steam pipes.

Sand House and Coaling Station
The T. W. Snow Construction Co.

Sand elevators, sometimes similar in form to coaling elevators, also are used, the hopper-bottom drying bin having a conical coil of steam pipe about the base, while the sand is sometimes elevated into the bin through a pipe by compressed air. An advantage of the elevated feature is gravity delivery through a pipe with a gate controlled by means of a line accessible to the operator on the locomotive.

SASH. The framed part of a window in which the glass is fixed by extension of the woodwork of a casement or glazed door.

A sash is commonly considered to include the panes of glass as well as the finished frame ready for hanging. There are two principal classes (1) sliding sashes (2) hinged sashes. A sliding sash usually is suspended in the window frame which is cased to form a recess in which the counterweight moves as the sash is raised or lowered. When the sash moves vertically, two sashes are set in one window frame, one above and sliding outside the lower one. This arrangement is called double hanging and the window is known as a double hung window. The two middle horizontal members of the sashes which close on each other when the window is shut are known as the meeting rails. The sashes of a casement window are hinged on the vertical edges to the sash frame, or the window may have only one sash. Casement windows open either in or out, an advantage of swinging out being tightness when closed, as the sash abuts on the outside of the frame. A disadvantage of casement sash is difficulty in screening and washing them and in hanging storm sash. Double hung sash tend to become loose at the meeting rail. Fixed steel sash with swinging ventilation panels are in general use, the ventilating panels having special operating devices.

SCALE. A balance used to measure the weights of objects.

Systems of weighing apparently antedated the use of money in measuring values as indicated by the most ancient known records of early civilizations. The lever scale is considered more dependable and is more generally used than the so-called spring balance, although both types have been in use in some form for many years. A primitive lever scale consists of a straight, stiff, slender beam supported at some central point on a pivot or knife edge, in order that an object suspended from a point near one end may be balanced by a standard weight suspended from the opposite end of the beam or from some point between the end and the pivot, the weight being read from divisions marked along the edge or side of the beam.

This principle of the lever is employed generally in scales, especially for weighing heavy loads, including the wagon types installed in warehouse floors for weighing package freight, in stock pens for weighing live stock, and on driveways or platforms for weighing truck loads of goods, as well as in the track scales of greater capacity for carload freight service. These scale mechanisms all have levers relatively suspended and inter-connected in such a way as to receive, distribute and transfer the loads to a beam suitably graduated and properly located to indicate the weights in pounds, etc., where they may be read conveniently by the operator. The primary object in having more than one lever, or a system of connected levers, is to obtain the required capacity, length, breadth and stability to properly measure the weights of the class of objects placed on the scale. Scale types differ chiefly by reason of the purposes for which the scales are used, these purposes determining their localities, capacities, forms and mechanisms. While in special cases scales are suspended from through trusses, the platform is usually at the level of the ground while only the steelyard rod, weigh beam, house, etc., are above the ground. The lower scale mechanism, consisting of the levers and their supports, is placed in the scale pit, usually a cubical concrete box, the top of which is the scale platform.

Desirable qualities in a scale pit are that the floor shall be above the level of the ground water, that it shall be on a solid foundation so situated that it may be drained readily, that it shall be large enough to afford ample room for inspection and that it shall be well lighted and ventilated. The scale parts, being of metal, require protection from rust, while the balancing mechanism must be free from corrosion and so situated that it may be minutely inspected and adjusted to be accurate. The platform is constructed so that it fits freely inside the frame, binding nowhere when a load is applied, yet oscillating so little as not to disturb the scale mechanism. The grades of approaches to scales depend on the manner of weighing the loads. Usually the scale itself is placed on a level grade unless it is to be

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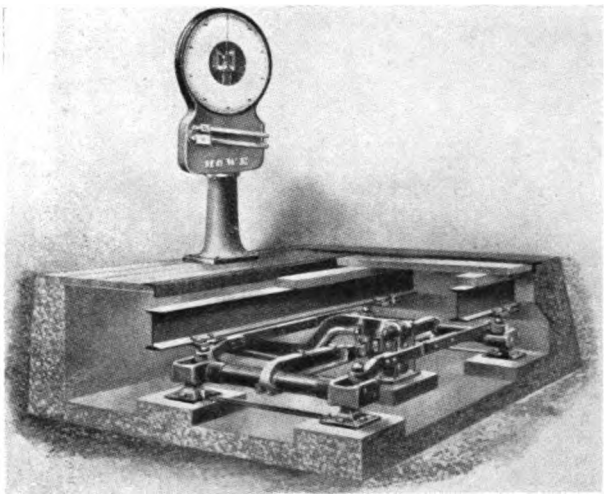
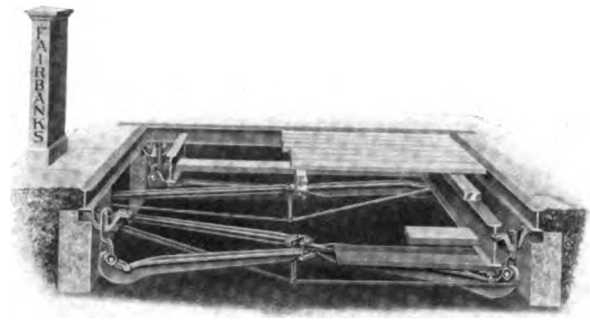
used for motion weighing, when it is placed on as light a grade as is feasible. Where the scale is located out of doors, the weigh beam is protected from the weather in a small shed or room called the weigh house which is commonly large enough only for a person to walk back and forth behind the beam stand, while one door is provided, as well as one or more windows suitable for throwing light on the scale beam so that the indications may be observed accurately and readily.

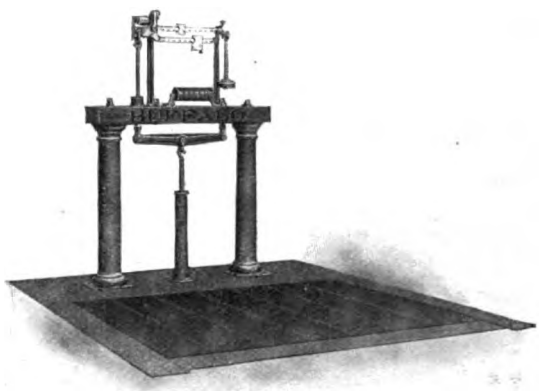
The scale beam supports consist usually of a substantial table formed of a horizontal shelf on pillars which are secured to the weigh house floor, and of two vertical metal frames, one at the supported end of the beam between the uprights of which the beam is hung, and another near the end of



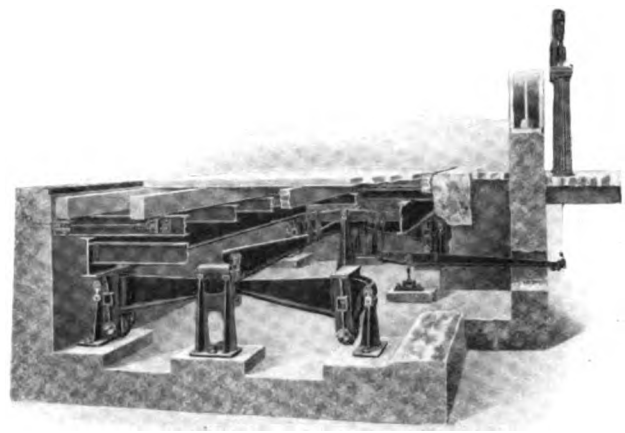
Freight House Scale
The Howe Scale Co.



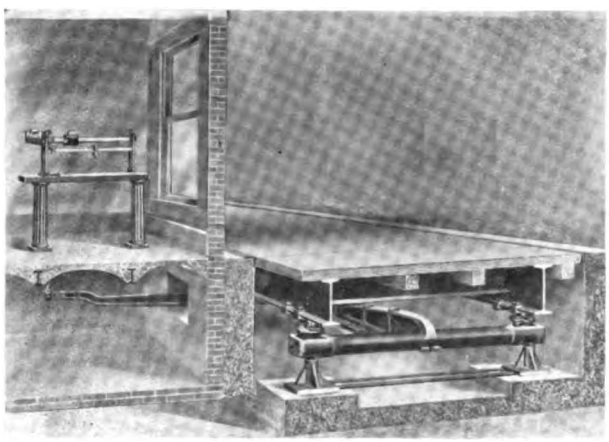
Wagon Scale
Fairbanks, Morse & Co.
(See Page 687)



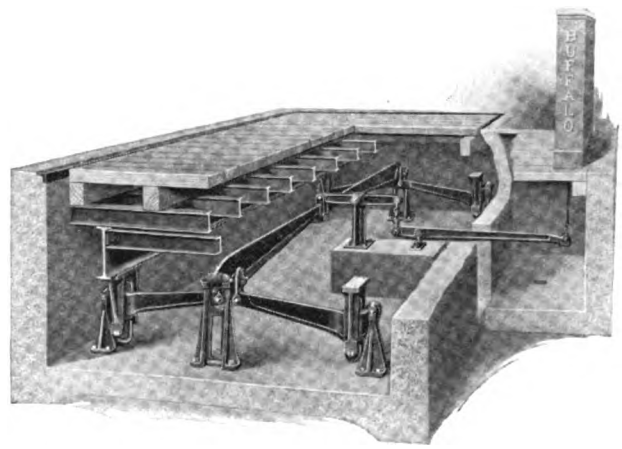
Railway Depot Scale
The Buffalo Scale Co.



Truck Scale
Fairbanks, Morse & Co.
(See Page 687)



Auto Truck Scale
The Howe Scale Co.



Buffalo Motor Truck Scale
The Buffalo Scale Co.

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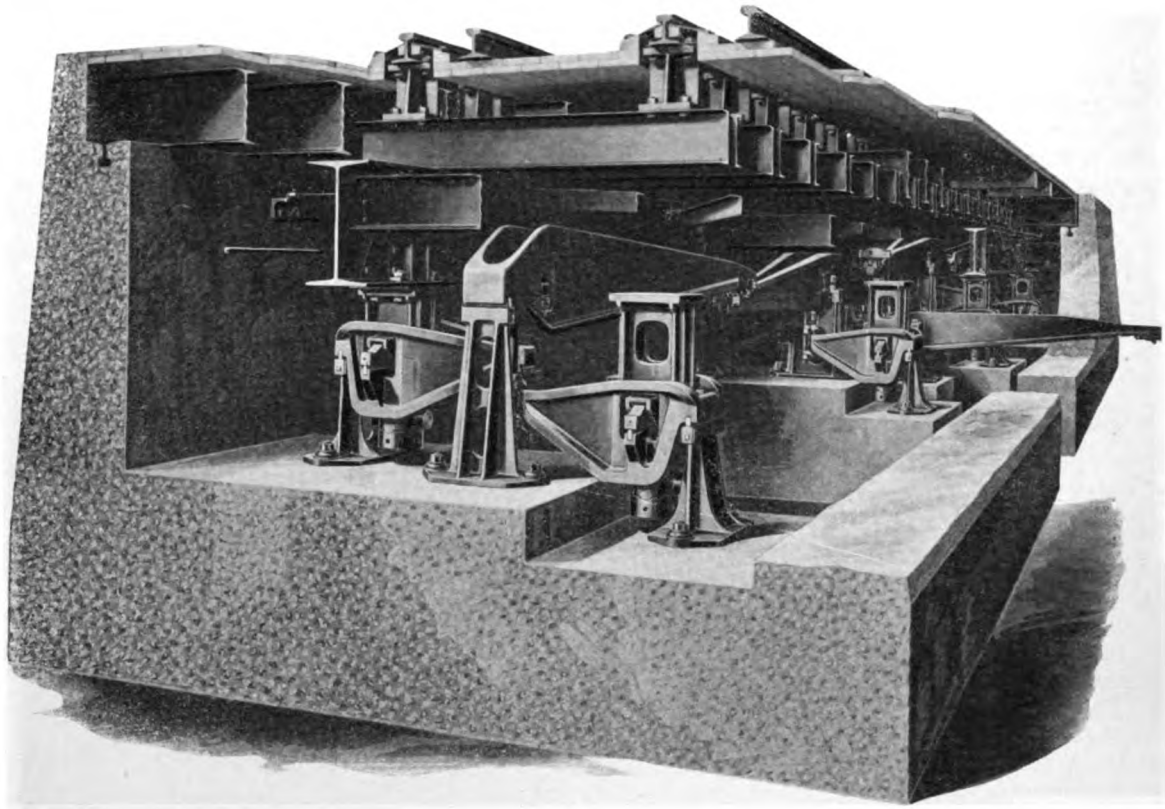
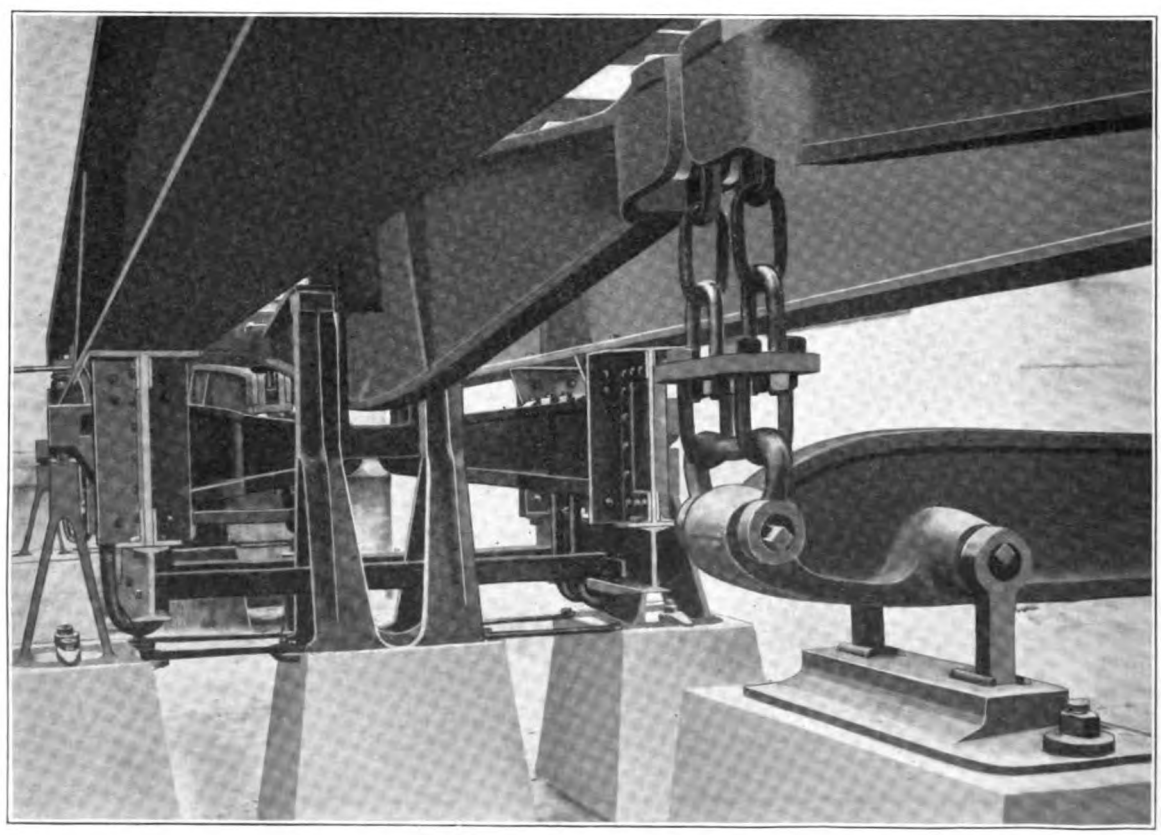


Track Scale
Fairbanks, Morse & Co.
(See Page 687)



Track Scale
The Standard Scale & Supply Co.
(See Page 813)

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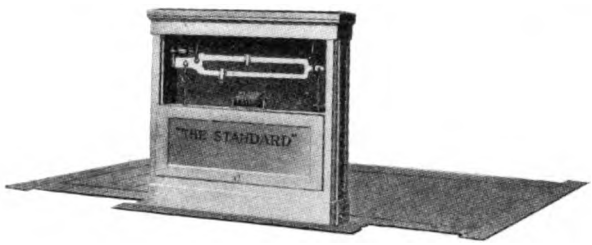
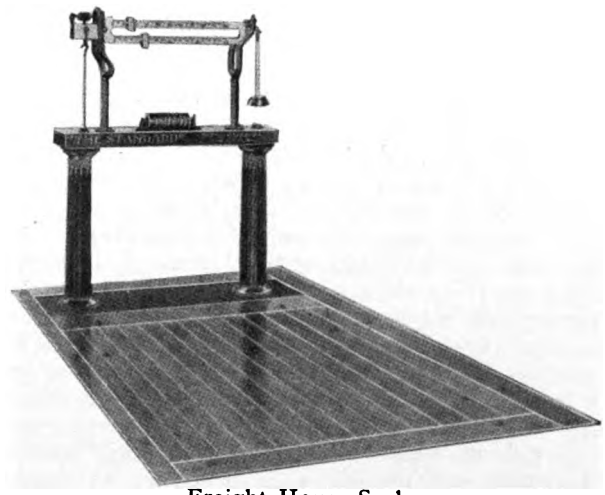
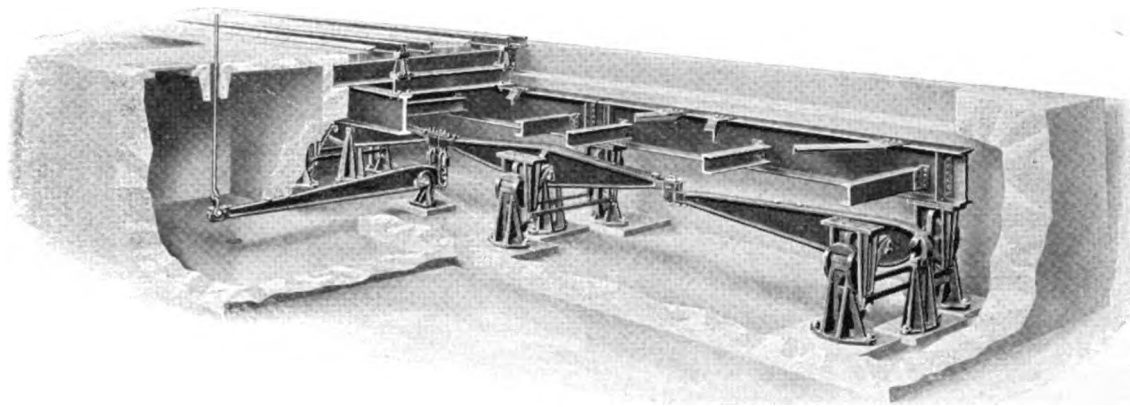
the long arm which serves as a guide and as a vertical stop to the tip. The bearing is a loop from which the scale beam depends, while a back-balance weight hung at the end of the short arm preserves the balance of the beam, and a ball moving on a short horizontal axle mounted on standards above the short arm serves as an adjusting device. A metal poise sliding on the beam indicates the



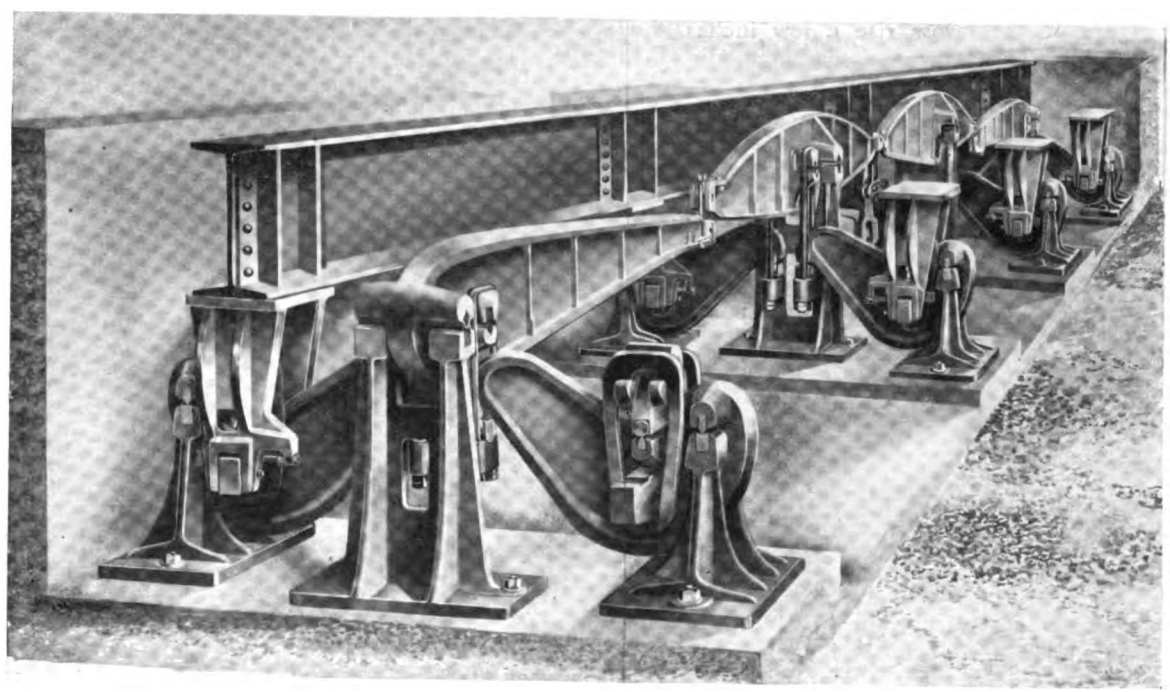
Wagon and Stock Scale
The Standard Scale and Supply Co.
(See Page 813)



Freight House Scale
The Standard Scale and Supply Co.
(See Page 813)



Track Scale
The Buffalo Scale Co.



Straight Lever Track Scale
The Howe Scale Co.

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weights sometimes only in large increments in which case smaller increments are shown by a secondary poise sliding on a fractional bar moving in grooves in the lower edge of the beam.

Hanger weights are not commonly used on heavy capacity scales, the beam being designed usually to show the entire weight. Beams are sometimes compounded, having two parallel indicating bars, one above the other, the poise between them sliding on both. At the fulcrum of the beam is a depending loop which engages the top hook of the vertical hanger rod, its bottom hook being held in the end loop of the long arm of the horizontal shelf lever, which is fastened at its opposite end with a loop and a bolt to the scale beam shelf above it. The maintenance of sufficient clearance where these levers and rods pass through the foundation and floor of the scale and the house is necessary to correct weighing.

Track Scales

Scales for weighing carload freight are located at junctions and at various other points along a line of railway where freight shipments originate or are concentrated. Necessarily such a scale must have a weigh bridge over which a track extends, in order that cars may be placed on or passed over it to weigh them. As many trains commonly pass a scale for other purposes than to weigh cars, a special weigh track is provided to indicate and make safe the business of weighing. A scale track is usually a comparatively short double ended siding gauntleted over the scale to minimize the number of movements over the live rails which bear on the weigh bridge while the dead rails bear on rigid foundations, one dead rail line being supported on the pit wall and the other on a series of rail stands secured to the floor of the scale pit. This gauntlet arrangement terminates at special switches beyond the ends of the scale approaches. Blocks of masonry or pedestals designed as bases for the steel castings which support the levers rise a few inches above the pit floor. The track scale is commonly 50 ft., 56 ft., or 60 ft. long, in which lengths two types are made, (1) heavy service scales having sectional capacities of 75 tons or 100 tons and (2) light service scales having sectional capacities of 60 tons or 75 tons.

The scale mechanism is usually in four sections, each section consisting of a pair of transverse main levers, the adjacent ends of which connect along the center line of the scale with a series of longitudinal extension levers which serve to transfer the loads to a transverse extension lever reaching to one side and in turn connecting with and transferring the load to an upright steelyard rod. This rod ends in a top hook which engages a loop on the scale beam or on a horizontal shelf lever which transfers the load to the beam.

The scale levers are supplied with pivots or knife-edged bars of special steel, the edges resting on the surfaces of special steel bearing blocks. Each main lever has three pivots, (a) the load pivot, (b) the fulcrum pivot and (c) the power pivot. The load pivots are those which first receive the load through the platform bearings on which the main girders of the weigh bridge are bolted. The ends of the levers are connected by means of large, steel links enclosing saddle blocks as bearings for the power pivots. The bearings are blocks of metal equal in quality to and a little harder than the pivots, and having indented surfaces, usually of shallow trough shape. If these bearings are cut by the knife edges they prevent correct weighing and must be replaced or reground to perfect surface to properly transfer the loads.

The main and extension levers must be exactly horizontal with all bearings in line while the upright connecting rods must be plumb to obtain exact weights. The levers must be free from horizontal deflection or warp to avoid torsional strains. The tip of one main lever of a pair is placed directly above or below that of its mate, the combined pull being in a straight line to the center of the bearing, which is in the center line of the extension levers. Each lever is preferably provided with independent adjustments, and the weight of the weigh bridge is adjustable to equal support on all its bearings.

Track scales are tested by means of standard weights, each section being tested separately and two or all in combination. Test cars of known weights, preferably four-wheeled cars containing movable weights are also used to test the scales in similar manner. These cars are tested on master scales which are under the jurisdiction of governmental bureaus and weighing associations. It is considered good practice to inspect a scale at least once in every two weeks, to adjust it if necessary and to maintain it in otherwise first-class condition, as the revenue derived from the transportation of freight depends directly on the accuracy of the weights obtained.

Wagon Scales

The wagon type of scale is commonly a pit scale with levers and a weigh bridge for wagons, trucks, stock or package freight. When installed out of doors it is subject to most of the conditions and should be maintained in a manner comparable with the track scale. The wagon scale pit, usually 22 ft. or not so deep as the track scale pit, usually 22 ft. or less in length and of capacities of 7,000 lb. or less. The pit is preferably of masonry, concrete being frequently used as well as stone masonry and brick, while many pits are walled with framed timbers, although this is not recommended.

The levers usually depend from a rectangular frame of steel channels or I-beams, or wooden beams anchored on the tops of the pit walls. The pivots are suspended by means of hooks clamped to the bottom of the frame and engaging links of the corner bearings. Usually the two main levers are thus attached to the corners of the frame opposite the weigh house under which they converge in V shape, their tips being held in a shackle casting from which the steelyard rod ascends to the shelf lever as in the track scale. The main levers are sometimes trussed, while two levers with bearings at the corners of the frame nearest the weigh house connect at the same shackle with the main levers, or each connects with the nearest main lever on the center line of the frame.

Another type of wagon scale has bearing stands within the pit, resting directly on the floor or on raised pedestals, while there are no outside frame,

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corner irons or check rods. Two main levers of this type occupy the center line of the scale, with nose bearings in loops depending from a transverse extension lever, the back end of which is also supported on a bearing stand while the tip connects with the steelyard rod. Some wagon scales have dial indicators instead of scale beams. The device which moves the dial is a double pendulum placed behind the face and adjusted to swing in ratio to the weights transferred from the scale platform to give the correct movement of the indicator.

Some scales are provided with bins or hoppers and are used to weigh bulk materials to be placed in and dumped from the container, such as bulk grain, coal, etc. Some freight house scale beams are equipped with magnifying attachments for reading weights at a distance.

SCALE BEAM. A graduated flat steel rod suspended on edge at one point near the butt from a framework on a scale beam table, and situated above or near and connected with a scale, from which loads are transferred in order that the weights may be indicated by poising the beam in an exact horizontal position.

Some scale beams have hanger weights at the tip to supplement the indications on the beam while others are graduated for full weights, notably the beams of heavy capacity track scales. Some beams are compound, consisting of two parallel, connected rods one above the other, with the poise sliding between and in contact with both rods.

The beam is free to move within the limits of the trig loop which confines it at the tip end within a vertical space equal to 2 per cent of its distance from the fulcrum bearing. See Scale. Also Scale, Track.

SCALE LEVER (Floating). A lever which exerts an upward pull at its fulcrum.

A floating lever is so anchored to the foundation that it is capable of resisting twice the uplift exerted by a capacity load. See Scale, Track.

SCALE, MASTER. A scale used for the weighing of test cars and for the verification of their weights.

A master scale is installed under cover on foundations of insured stability and in some position remote from vibrations such as might be caused by trains, etc., in order that extreme accuracy may be attained by means of the two-section track type of scale, which should have a capacity of 100,000 lb. or more. The master scale beam has a capacity of 100 lb. and is graduated to 5-lb. divisions, while the length of weighing rail is at least 10 ft.

SCALE PIT DRAINAGE. Any means adopted to lead water out and away from a scale pit with a view to preventing dampness from rusting the scale.

The consideration of drainage includes the location of the scale at such an elevation relative to the surrounding ground that a falling grade from the pit can be obtained. The floor of the pit is sloped to drain to a central outlet point or points, while the walls and floor are made impervious to water if possible, usually by construction of first-class concrete masonry in proportions of 1:2:4 or a richer mixture with or without waterproofing compounds or coatings. In case a falling grade sufficient to drain the pit is not obtainable, a cistern may be dug at a suitable distance from the scale into which the water is drained by gravity and from which it is pumped to waste. If the pit must resist the pressure of water of a higher normal level than the floor, the entire pit is waterproofed, usually with a bituminous liquid or fabric or both and frequently with other compounds. The chief difficulty in excluding water is to obtain the faultless workmanship necessary to perfect every portion of the concrete pit, the water usually finding its way through weak spots at some joint.

Surface drainage may prevent water from entering the pit, excepting that which falls on the platform and wall tops. Metal weather strips and other similar devices are used to exclude this water, while snow is swept from the surface and if possible the scale pit is heated in winter to prevent ice from forming as well as to keep the air dry, eliminating moisture and tending to prevent the hardening of the lubrication on the bearings, etc. The small amount of rain falling on a scale platform is only serious because no moisture should be allowed in the pit, that which finds its way in being disposed of as described above. See Scale Pit Ventilation.

SCALE PIT VENTILATION. Any process tending to eliminate moist air from a scale pit, with a view to preventing the rusting of the scale parts, especially the knife edges and bearings.

Ventilation at the natural air pressure is preferred to a forced draft, as being the surest way to keep a pit dry under all atmospheric conditions. The outside air may be damp and moist when the pit is cool and dry, contact with the outside air in such a case being undesirable as it might lead to condensation or sweating of the walls and metal surfaces. A system of flues is recommended by the National Bureau of Standards, the flues extending down from the deck almost to the floor of the pit, while other openings are also made in the deck independent of the flues, for egress of the air from the pit when it is lighter than the outside air. This escape of light air causes a draft of outside air down the flues, until the pressue is equalized, while if the pit air is the heavier the draft is reversed. Warm air being lighter than cool air and moist air being lighter than dry air, this method of circulation tends to allow moist air to escape and warm air to enter the pit and reduces sweating to a minimum although it cannot always be prevented entirely. See Scale Pit Drainage.

SCALE, TRACK. A Scale with a weigh bridge supporting a section of running track for the purpose of obtaining the weights of rolling stock, usually cars and carloads of freight.

Track scales are of two general types, the straight lever and the pipe or torsion scale. The straight lever scale has weighing parts designed for horizontal and vertical action only, while the torsion scale parts twist under loads. Some track scales are furnished with automatic weight recorders which are especially useful in motion weighing where scales in hump yards are placed on suitable grades and the cars are uncoupled and allowed to drift, one by one, down the grade and over the scale to be weighed, and reassembled later.

The following specifications for the manufacture and installation of railway track scales, prepared

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by a joint committee representing the A. R. E. A., the A. R. A., the U. S. Bureau of Standards, the Railroad and Warehouse Commission of Minnesota, the National Scale Men's Association and the Scale Manufacturers' Association, have been adopted by the A. R. E. A.

The object of these specifications, which apply to new installations of knife edge scales of the straight lever and torsion lever types for weighing cars in freight interchange service, is to obtain reasonable uniformity without standardizing so inflexibly as to exclude or prevent the adoption of improvements in the scales or scale parts. They introduce provisions for two classes of scales: a light service type and a heavy service type. These classes differ in features affecting wear in use, but not in strength for given capacities, the heavy type being intended for ordinary railway and industrial installations, while the light service type is proposed for locations where the use is restricted to weighing 20 cars or less per day. Authority, Western Weighing Association.

Special cases where the types proposed would not be suitable are not covered, except by a recommendation that the materials, workmanship, etc., shall be at least equal to similar requirements of the specifications, the principles of which should be followed as far as they may apply.

Section I—CLASSES OF SCALES

1. **Character of Classification:** Scales shall be divided into two classes, namely, **heavy service scales** and **light service scales;** and except when otherwise specifically provided these specifications are to apply to both classes of scales.

(a) **Heavy Service Scales:** Heavy service scales are those over which a large number of cars are to be weighed; and they shall have sectional capacities of 75 to 100 tons, except for special cases.

(b) **Light Service Scales:** Light service scales are those over which relatively only a few cars are to be weighed; and they shall have sectional capacities of 60 or 75 tons, except for special cases.

2. **Special Cases:** For special cases which cannot be covered in these specifications, it is recommended that the material, workmanship, etc., shall be at least equal to that required in these specifications, and that the principles herein set forth be followed in so far as they apply.

Section II—CAPACITY

1. **Capacity Defined:** The capacity of a scale is equal to the weight of the heaviest car it will weigh, provided that the scale will support a train of such cars passing over the scale without stresses being developed in the members of the scale which are in excess of those hereinafter specified. The car weight for a given sectional capacity and given length of scale is shown in table for scale capacities and weigh-bridge girders, section XXIV.

2. **Capacity Required:** The capacity of the scale shall be sufficient to meet the requirements of the heaviest service to which it may be subjected.

3. **Sectional Capacity:** The sectional capacity of the scale is the greatest weight which, if applied on the load knife edges of each pair of main levers, will produce stresses in the scale parts not exceeding those given in the table of working stresses, section IV.

Section III—PLANS

1. **Plans:** The manufacturer shall furnish to the purchaser plans of design showing stresses and detailed dimensions for all scale parts, and the material of which they are to be fabricated; also assembly plans showing location of all field connections and all information necessary for the purchaser to design and construct the pit and parts not furnished by the scale manufacturer.

Section IV—WORKING STRESSES

1. The following unit stresses shall not be exceeded when the scale is loaded to its capacity as defined above. These stresses include an allowance for impact caused by moving loads. The strength of each member shall be determined by its weakest cross-section.

2. **Iron and Steel, Working Stresses in Pounds Per Square Inch:**

					Steel for Pivots and Bearings	
Nature of Stress	Cast Iron	Steel Castings	Machinery Steel	Structural Steel	High Carbon	Special Alloy
Tension	1,500	8,000	8,000	10,000		
					24,000	30,000
Compression	8,000	10,000	8,000	10,000		
					24,000	30,000
Transverse Bending—						
Tension	2,500	8,000	8,000	10,000		
					24,000	30,000
Compression	8,000	10,000	8,000	10,000		
					24,000	30,000
Shear	2,500	6,000	5,000	7,000	.....	.....
Torsion	2,500	6,000	.....	7,000	.....	.....

The bearing stress on steel pins shall not exceed 15,000 pounds per square inch.

3. **Knife Edge Bearing Stresses:**

(a) **Heavy Service Scales:** For heavy service scales the load per linear inch of knife edge shall not exceed 5,000 lb. for high carbon steel or 6,000 lb. for special alloy steel.

(b) **Light Service Scales:** For light service scales the load per linear inch of knife edge shall not exceed 6,000 lb. for high carbon steel or 7,000 lb. for special alloy steel.

4. **Concrete Bearing Stresses:** Stresses to be allowed for bearing on concrete shall not exceed 300 lb. per sq. in. under scale lever stands, and at all other points shall not exceed 400 lb. per sq. in.

5. **Loops, Formula for Stresses:** Considering the end of the loop as a simple beam, its section at the point of maximum bending shall be determined by the formula $\frac{W}{4}\left\{L-\frac{1}{2}\right\}$ wherein W equals the maximum load applied to the loop, L equals the distance between the center lines of the depending sides, and l equals the distance over which the load is distributed.

6. **Projecting Pivots, Formula for Stresses:** Where practicable, the pivots shall be supported their full length by integral parts of the lever. Where impracticable to so support the pivots, the bending moments shall be determined as follows:

Let W equal the total load on both ends of pivot in pounds.
L " the moment arm in inches.
l " the length of bearing in loop, in inches.
T " distance between friction faces of loop, in inches.
B " the width of boss or sustaining member enveloping pivot, in inches.
M " bending moment in pivot, in inch pounds.

Then:

L equals ½l plus (T-B) plus ¼ in.

and:

$$M \text{ equals } \frac{WL}{2}=\frac{W}{2}[\tfrac{1}{2}l \text{ plus } (T-B) \text{ plus } \tfrac{1}{4} \text{ in}].$$

Section V—LENGTH OF SCALE AND NUMBER OF SECTIONS

1. **Scale Length Defined:** The length of a scale shall be considered as the effective weighing length of the live rails. In no case shall this effective weighing length be greater than the distance between the centers of end sections.

2. **Scale Lengths Standardized:** The lengths of scales, except in restricted traffic movements, or for special cases, shall be 50, 56 or 60 ft.

3. **Number of Sections:** Scales of 60 ft. or less in length shall not be constructed in more than four sections.

4. **Motion Weighing:** When cars are to be weighed in motion, the speed shall not exceed four miles per

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hour, and each car shall be entirely and alone on the scale a minimum of three seconds. This condition applies to cars normally weighed. When scales are of such a design or length as not to permit of the above condition, cars shall be spotted to secure accurate weights.

Section VI—SCALE LEVERS

1. **Qualities of Castings:** The finished levers shall not be unduly warped; they shall be free from blisters, large holes or other imperfections, and shall be brought to a reasonably smooth finish.

2. **Machined Ways for Nose Irons:** Levers that are to be equipped with nose irons shall have those portions of the lever ends receiving them machined for the full distance over which the nose irons are to move.

3. **Leveling Lugs:** In scales of the straight lever type each lever shall be provided with leveling lugs for longitudinal alinement. In scales of the torsion lever type, leveling lugs shall be provided on the pipe or torsion member for transverse alinement and on the extension arm for longitudinal alinement. Each pair of lugs shall be spaced 11 in. The leveling surfaces of each pair of lugs shall be finished to a common plane which shall be parallel to the plane established by the knife edges of the end pivots.

4. **Marking of Levers:** Figures denoting the multiple of each lever shall be cast or otherwise permanently marked in plain figures thereon.

5. **Length, Allowable Variation:** All main levers shall be true to within ⅛ in.; and all extension levers shall be true to within ¼ in. of their nominal lengths between the knife edges of end pivots.

6. **Loading of Levers Other Than Main Levers:** In establishing the load for determining the stresses in the levers other than main levers, it shall be assumed that the end extension levers carry a total live and dead load corresponding to 100 per cent of the sectional capacity; the portion of the middle extension levers carrying the load from the end section only, 100 per cent of the sectional capacity; and the portion of the middle extension levers carrying the combined load from the end section and inner section, 160 per cent of the sectional capacity; the transverse extension lever, shelf lever and beam, 300 per cent of the sectional capacity.

Section VII—PIVOTS AND KNIFE EDGES

1. **Material:** The requirements for physical properties of the steel used for pivots shall be as follows:

(a) **Special Alloy Steel in the Annealed State:**

Elastic Limit	Not over 75,000 lb. per sq. in.
Tensile Strength	Not over 110,000 lb. per sq. in.
Elongation in 2 in.	Not less than 20 per cent.
Reduction in Area	Not less than 35 per cent.

(b) **Special Alloy Steel Hardened:**

Elastic Limit	Not less than 160,000 lb. per sq. in.
Tensile Strength per sq. in.	Not less than 200,000 lb. per sq. in.
Elongation in 2 in.	Not less than 5 per cent.
Reduction in Area	Not less than 25 per cent.
Shore Hardness	Not less than 85.

(c) **High Carbon Steel in the Annealed State:**

Elastic Limit	Not over 55,000 lb. per sq. in.
Tensile Strength	Not over 117,000 lb. per sq. in.
Elongation in 2 in.	Not less than 15 per cent.
Reduction in Area	Not less than 25 per cent.

(d) **High Carbon Steel Hardened:**

Elastic Limit	Not less than 135,000 lb. per sq. in.
Tensile Strength	Not less than 180,000 lb. per sq. in.
Elongation in 2 in.	Not less than 3 per cent.
Reduction in Area	Not less than 12 per cent.
Shore Hardness	Not less than 85.

2. **Design.** All pivots shall be designed and manufactured so that the two sides joining to form the knife edge shall make an angle that will not exceed 90 deg.; that the tolerance for offset of the knife edge of the pivot, as figured from the center line of the pivot at its base, shall be within 10 per cent of the width of the pivot for "machined in" pivots, and 15 per cent of the width of the pivot for "cast in" pivots.

3. **Mounting:**

(a) **Fastening:** All pivots shall be firmly fastened in position, without swedging or caulking.

(b) **Machining:** For heavy service scales all pivots of the main levers shall be machined and fitted into machined ways.

(c) **Continuous Contact:** All pivots shall be mounted so as to secure equal and continuous contact of the knife edges with their respective bearings for the full length of the parts designed to be in contact; in loop bearings the knife edges shall project slightly beyond the bearings in the loops.

(d) **Position:** The pivots shall be so mounted that each knife edge in a given lever will be maintained in a horizontal plane under any load; and shall be so mounted that a plane bisecting the angle of a knife edge will be perpendicular to the horizontal plane established by the knife edges of the end pivots, and shall be so mounted that the knife edges in a given lever will be parallel to each other.

4. **Support for Projecting Pivots:** The reinforcing on the levers to support projecting pivots shall be tapered off to prevent lodgment of dirt next to the pivots and to provide proper clearances.

5. **Fulcrum Distance:** The distance between the fulcrum pivot knife edge and the load pivot knife edge in main levers of heavy service scales shall be not less than 8 in. For light service scales it is recommended that this fulcrum distance shall be not less than 6½ in.

6. **Location of Main Lever Load Knife Edges:** The load knife edges of the main levers shall be so located that the center line of the live rails can be placed in the vertical plane established by the centers of those knife edges.

Section VIII—NOSE IRONS

1. **Design and Fastening.** The nose irons shall be firmly fastened in proper position by means of screws or bolts of a recognized standard size and thread, or other equally effective mechanical device.

(a) **Design of Fastening:** The means for clamping the nose irons in position shall be of such design that indentations in the lever will not be made, and shall be independent of any means provided for adjustment.

(b) **Direction of Fastening:** The means for clamping nose irons in position shall force or hold them against the lever in the same direction as they would be forced by the load.

(c) **Control of Nose Iron Movement:** The movement of the nose irons shall be controlled by means of adjusting screws of recognized standard size and thread. These screws shall be made of a material which will not corrode.

2. **Marking of Position:** The position of each nose iron as determined by the factory adjustment, shall be accurately, clearly and permanently indicated by a well-defined mark on the lever and nose iron, which shall meet on a common line.

3. **Finish and Pivot Mounting:** Those surfaces of the nose irons intended to come into slidable contact with the levers shall be made true so as to secure an accurate fit of the nose irons on or in the levers. Each nose iron shall be of such design that when adjustments are made the knife edge will be held parallel to its original position.

Section IX—LEVER FULCRUM STANDS

1. **Design:**

(a) **Height of Pillars and Area of Bases:** The height of the pillars and the dimensions of the bases of the

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stands shall be sufficient to prevent a tipping action. In stands of the two pillar type, both pillars shall be of equal height.

(b) **Pillars, Position on Bases:** The pillars or upright portions of the stands carrying the bearings shall be so placed on the bases that the centers of the bearing lines shall be over the centers of gravity of the bearing surfaces of the stands.

(c) **Anchor Bolt Holes:** Two or more anchor bolt holes, not less than two inches in diameter, shall be provided in proper places in the bases of all the stands, unless other equally effective means for anchorage is provided.

2. **Qualities of Castings:** The castings shall be free from blisters and large holes, or other imperfections, and shall be brought to a reasonably smooth finish.

3. **Bases for Lever Stands:** The bases of the stands shall be finished to within a tolerance of 1/32 in., or machined when to be mounted on metal bed plates; accurate to a plane perpendicular to the axis of the upright portion of the stand, and the knife-edge bearing line shall be parallel to the surface of the base.

4. **Pillars, Finish of Tops:** The tops of the pillars for receiving the bearing steels, caps or blocks shall be finished to a tolerance of 1/32 in.

5. **Tie Bars.** Tie bars for the lever frames are not required, but if used, the contiguous surfaces shall be machined.

Section X—BEARINGS, BEARING BLOCKS AND LINKS

1. **Material for Bearing Steels:** The character of the material for bearing steels will be found under "knife edges," Section VII. The bearing steels shall be equal to or greater in hardness than the knife edges which oppose them. It is found good practice to have the bearing steels not less than 95 points hardness on the Shore recording scleroscope for high carbon steel, and not less than 90 per special alloy steel.

2. **Design of Bearings.** Scales shall be so designed that when the load is applied to the live rails, the oscillation of the weigh-bridge will not displace the bearings at points of contact on the knife edges.

3. **Mounting of Bearing Steels.** All like bearing steels shall be interchangeable or mounted in interchangeable bearing steel blocks. When the steels are separable and interchangeable in the blocks they shall be fastened in position by means of set screws of a recognized standard size and thread, and of a material which will not corrode, or by other equally effective device.

4. **Finish of Bearing Steels and Bearing Blocks:** The bearing surfaces shall be brought to a smooth, true and accurate finish to provide continuity of contact with the opposing knife edges.

5. **Weigh-Bridge Bearings:** The tops of weigh-bridge bearings making contact with the weigh-bridge girders shall be finished to within 1/32 in. of a true plane that will bring them all to the same height when in position, and in a plane parallel to the bottom of the bases of the fulcrum stands. These tops shall be provided with bolt holes of a sufficiently large diameter to allow for adjustment both transversely and longitudinally to secure a proper alinement of parts.

Section XI—LOOPS AND CONNECTIONS

1. **Design Proportion:** In loops which form bearings for projecting pivots, the radius of the portion of the bearing making immediate contact with the knife edges and the radius of the eye of the loop shall be not less than the length of the longest side of the cross-section of the pivot to be used in the loop.

2. **Length:** All loops in like connections, except where made adjustable, shall be of the same length.

3. **Steelyard Rod:** The steelyard rod shall be equipped with a turnbuckle.

4. **Lock-Nuts:** Bolts or turnbuckles used as a part of the connections shall be provided with lock-nuts.

Section XII—CHECKS

1. **Type:** All weigh-bridges shall be checked by adjustable checks of the rod or other approved type which shall be equal to the rod type in functioning.

2. **Character:** Both longitudinal and transverse checks shall be provided.

3. **Position:** The checks shall be attached as high as possible and shall be horizontal, and parallel with or perpendicular to the vertical plane through the center line of the track according to whether they are longitudinal or transverse checks.

4. **Number:** Not less than four longitudinal and eight transverse checks shall be provided. When the rod type is used, they shall be assumed to act in tension only.

5. **Strength:** The combined area in square inches of the check rods at either end or side shall be not less than the sectional capacity in pounds divided by 60,000 when steel check rods are used.

Section XIII—WEIGH-BEAM AND ACCESSORIES

1. **Design:**

(a) **Capacity:** The maximum capacity of the beam shall be not greater than 1⅓ times the sectional capacity.

(b) **Full Capacity Beam:** Except for special cases a beam of the full capacity type shall be provided.

(c) **Shoulder Stop:** A shoulder stop shall be provided on all beams to prevent the travel of the main poise back of the zero notch.

(d) **Notches:** The number of notches for the main poise shall not exceed six per in. Each notch shall be so made that when the pawl rests in it a line projected from the center of the side of the notch nearer the zero graduation to the axis about which the pawl revolves will be perpendicular to that side of the notch.

(e) **Pawl or Latch:** The tip or point of the pawl or latch shall be of the same width as the notches of the beam, and shall be rounded off so that a small amount of dust or dirt in the bottom of the notch will not prevent the poise from assuming its correct position.

(f) **Projections and Recesses:** Poises shall be designed so as to present the least number of recesses or projections in or on which dust or dirt may accumulate.

(g) **Ball or Cone Bearings:** Ball bearings, cone bearings or other means shall be provided to secure as free a movement of the poise along the beam as possible, but without sideplay of the poise.

(h) **Registering Beam:** Scales that are to be used exclusively for spot weighing of cars or carload freight shall be equipped with a type registering, or other registering beam, of a capacity that will enable the entire load to be weighed in one draft, and without the use of additional weights of any kind, except for special weighing.

(i) **Fractional Bar Stops:** On registering beams the fractional poise shall be equipped with means to insure a positive stop at any 20-lb. interval, and a stop shall be provided to prevent the movement of the fractional bar beyond its proper travel in either direction.

(j) **Operating Lever:** A substantial double or other approved type of hand grip shall be provided to facilitate the printing or registering of the weight on the ticket with the least possible disturbance of the beam.

(k) **Receptacle for Weight Ticket:** On registering beams means shall be provided to prevent the placing of the weight ticket in its receptacle in any position in which an incorrect weight can be registered.

2. **Marking:**

(a) **Intervals:** The notches and graduations on the main beam shall be made at the 1000 lb. intervals.

(b) **Length of Graduations:** For the main beam the zero graduation and all graduations representing multiples of 10,000 lb. shall be ¾ in. in length. All graduations having values in thousands of pounds ending in 4 and 8 shall be ½ in. in length. All other graduations shall be ¼ in. in length, or the alternative method of marking may be used in which the marks represent-

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ing 5, 15, 25, etc., thousand pounds shall be not less than 1½ times the intermediate lines, and every tenth line shall be longer than every fifth line, and the lengths of the graduations other than the 5s and 10s shall be not greater than twice the distance between their centers, preferably 1½ times the distance between their centers.

(c) **Size of Figures:** For the main beam the zero graduation and every tenth graduation therefrom shall have its value in thousands of pounds (i. e., 0, 10, 20, etc.) marked by figures ⅜ in. in height, except the last graduation on beam, which shall be marked in full, for example, 200,000 lb. All other graduations, in beams graduated by the first method, having values in thousands of pounds ending in an even figure, namely, 2, 4, 6 and 8, shall be marked by figures $\frac{3}{16}$ in. in height. On beams graduated by the second method, the 5s, 15s, etc., may or may not have the value in thousands of pounds marked, or may have a star or other device placed opposite the line. No other graduations having readings in thousands of pounds ending in an uneven figure shall be marked. All numbers shall be placed directly beneath their respective graduations and shall be within $\frac{1}{16}$ in. to ⅛ in. of the graduation.

(d) **Fractional Beam:** For registering beams the graduations for the fractional beam shall be placed at 20-lb. intervals up to and including 980 lb., or if the fractional beam corresponds to a full 1000 lb., the last figure shall be marked to read 999 lb. Non-registering fractional beams shall be graduated in 50-lb. intervals, except for special cases.

3. **Balance Ball:** A balance ball shall be provided and its movement shall be controlled by means of a self-contained hand operated screw or other device which will not require that the ball be rotated in making any adjustments. A means for locking the ball in position shall be provided. The balance ball shall be provided with vertical adjustment.

4. **Counterbalance Weights:** If counterbalance weights are to be used, the lower end of the hanger stem shall be threaded; a cup for the loose balancing material shall be screwed to the lower end of the stem and each additional weight shall be provided with an elongated hole in the center through which the hanger stem may pass. No slotted counterbalance weights are to be used. When no counterbalance weights are necessary on top of the counterbalance cup the cavity shall be closed by a cover, secured in a positive manner. No counterbalance weights shall be used in any place in the scale, except at the beam.

5. **Multiplication:** A pivot with a loop shall be provided at the tip of the beam. The multiplication to this pivot knife edge shall be 7000 or 10,000, which shall be plainly and permanently stamped on the beam.

6. **Identification of Parts:** Each beam shall be given a serial number which shall be stamped on the beam. The pivots, poises and fractional bar shall have stamped on them identification marks to show to which beam each belongs, and the pivots shall be so marked as to indicate their proper positions in the beam.

7. **Type Figures:** Type figures shall be made of a material sufficiently hard so that they will not easily become battered or defaced. The figures shall be plain and raised sufficiently high to insure a clear impression when the weight ticket or tape is stamped. They shall be so attached and secured in their proper places that they will not become loosened.

8. **Beam Fulcrum Stand:**

(a) **Design:** The beam shall be supported on a stand provided with compensating bearings, and shall not be suspended. The height of the pillars and the dimensions of the base of the stand shall be such as to prevent a tipping action.

(b) **Height:** The height of the stand, measured from the bottom surface of the base to the pivot bearing surface, shall not exceed 13 inches.

(c) **Finish:** The bearing surface of the base of the stand shall be finished to a plane perpendicular to the axis of the upright portion of the stand, and the knife-edge line of the bearing shall be parallel to the base. The center of the bearing line shall be vertically over the center of gravity of the bearing surface of the base.

9. **Trig Loop:**

(a) **Material:** The contact parts of the trig loop shall be made of a non-magnetic material.

(b) **Play of the Beam:** The play of the beam in the trig loop shall be not more than 2 per cent of the distance from the trig loop to the knife edge of the fulcrum pivot.

(c) **Pointer:** The beam shall be fitted with a pointer to be used in connection with a fixed graduation or other device on the trig loop to indicate a central position in the trig loop when the beam is horizontal.

10. **Beam Support:** Cast-iron pillars or equivalent and a beam shelf shall be provided for all scales. The beam fulcrum and the trig stand shall be securely erected thereon. This shelf shall be strong and sufficiently rigid, so that it will not deflect to an extent that the action of the scale will be affected.

Section XIV—ANTI-FRICTION POINTS AND PLATES

1. **Required:** Anti-friction points and plates shall be provided to limit the relative lengthwise displacement of all knife edges with respect to their bearings.

2. **Material:** The anti-friction points and plates shall be made of hardened carbon steel and the plates shall be at least as hard as the points which come in contact with them.

3. **Design:** The anti-friction points shall consist of a point or projection of small area formed on the knife edge, in the case of full length contact knife edges, or shall be formed on plates securely attached to the levers or pivots. The design of the anti-friction points shall be such that they will always make contact with their opposing plates on the line of the knife edges, within practical limits. In loop bearings the parts which come in contact with the anti-friction points shall be formed without any points or projections so that, when the loop is relatively displaced in a direction at right angles to the knife edges, the contact will continue to be made with the anti-friction points on the line of the knife edge.

4. **Clearances:** The clearances between the anti-friction plates and anti-friction points shall not exceed $\frac{1}{16}$ in. on the beam, ⅛ in. on the shelf lever, and ¼ in. on all other levers, and the minimum clearances shall be not less than one-half these amounts respectively.

Section XV—CLEARANCES

1. The clearance around and between the fixed and live parts of the lever system of a scale shall be at least ¾ in. except at points where other clearances are specified.

Section XVI—FACTORY ADJUSTMENTS

1. **Levers:** The design, workmanship, and factory adjustment of the levers and beam shall be such that the proper ratio of the lever arms will be maintained.

2. **Beams:** Each notch in the beam shall be adjusted to within .002 in. of the nominal distance from the zero notch.

Section XVII—INTERCHANGEABILITY

1. Like parts of all like scales of the same design and manufacture shall be interchangeable unless otherwise herein specified. The scale drawings and the parts of the scale shall be marked to indicate the proper positions of the parts in the scale, so as to prevent parts not symmetrically designed being incorrectly placed when the scale is set up.

Section XVIII—SENSIBILITY RECIPROCAL

1. **Definition:** The sensibility reciprocal shall be that weight required to be added to or removed from the live rails to turn the beam from a horizontal position of equilibrium in the center of the trig loop to a position of equilibrium at either limit of its travel.

2. **Value:** The sensibility reciprocal shall not exceed 50 lb. in any case.

Section XIX—TOLERANCE

1. The Manufacturers' tolerance to be allowed on the first field test, after installation corrections, of all new railroad track scales shall not exceed 1/20 of 1 per cent, or 50 lb. per 100,000 lb., for any position of the test car

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load on the scale. The minimum test car load to be applied shall be 30,000 lb.

Section XX—LOCATION AND ELEVATION

1. **Foundation:** Scales shall be so located that an adequate foundation, and at least 50 ft. of tangent track at each approach to the live rails, can be provided.

2. **Elevation:** The scale shall be raised with respect to the other tracks of the yard to such an elevation that the drainage of the surface water will be away from it. Means shall be provided to prevent surface water between the rails of the scale tracks from running into the pit.

3. **Right-Handed Beam:** Scales shall be so located that a right-handed beam can be used in all cases without the use of extension levers, exclusive of shelf lever, between transverse extension lever and beam.

Section XXI—FOUNDATIONS

1. **Material:** All scale foundations shall be constructed of concrete. The qualities of the materials and the methods of mixing and placing the concrete shall be in accordance with the railroad's specifications for first-class concrete, or other first-class engineering practice may be followed.

2. **Bearing Area:** The bearing areas of the foundation footings shall be such that the bearing pressure on the soil will be uniform throughout and not exceed:

For fine sand or clay	4,000 lb. per sq. ft
For coarse sand and gravel or hard clay	6,000 lb. per sq. ft.
For boulders or solid rock	20,000 lb. per sq. ft.

If the soil has not a safe bearing capacity equal to that of fine sand or clay, its bearing capacity should be increased, by drainage, by adding a layer of gravel or broken stone, or by driving piles.

3. **Dimensions of Pit:** The depth of the scale pit shall be not less than 7 ft. from the base of the rail to the finished floor of the pit. The width of the pit between faces of side walls shall be not less than 10 ft. for light service scales, or less than 10 in. for heavy service scales, provided that there shall be a horizontal clearance of not less than 16 in. between the faces of the side walls and the scale parts below the weigh-bridge girders and above the base of the stands. The length of the pit inside of end walls shall be not less than 2 ft. greater than the length of the scale parts.

4. **Walls of Pit:** The side and end walls shall be not less than 15 in. and preferably 18 in. thick at the top. The foundation walls of the scale house shall be not less than 12 in. thick at the top and shall be formed solidly to the side walls of the scale pit.

5. **Waterproofing:** Where necessary to prevent seepage of water through foundations into the scale pit, they shall be waterproofed and drained into a waterproofed cistern located outside the scale pit and equipped with either pump, siphon or automatic "cellar drainer."

6. **Approach Walls:** Approach walls or piers of concrete shall be built to extend at least 15 ft., preferably 25 ft., from the pit face of the end wall at the approach and back under the track, to preserve line and surface of approach tracks. They may be built in one solid mass of concrete or they may consist of two parallel walls or piers, but with either type of construction they shall have a single foundation footing. Where necessary to secure safe bearing capacity they shall be carried to the same depth as the pit walls.

7. **Wall Batter:** All wall surfaces next to earth subject to freezing shall be constructed with a uniform batter of not less than 1 in. to the foot, and as much more as necessary to permit the heaving of adjacent ground by frost action without disturbing the walls.

8. **Footings or Piers for Lever Stands:** The concrete footings or piers supporting the lever stands shall be not less than 18 in. thick. Their tops shall be above the floor of the pit a distance sufficient to prevent the accumulation of water under the bases of the stands, and they shall be finished to exact level and elevation to receive the lever stands directly without the use of shims or grouting. The floor of the pit may be a solid mat of concrete nearly the same thickness as that required to support the lever stands, or it may be not less than 6 in. thick where local conditions permit. The pit floor shall in all cases be smooth and with a pitch to a common point of drainage and free from pockets in which water will stand. If the scale is of a type having main levers or parts of the platform bearings that hang below the bases of the main lever stands, the piers shall be provided with recesses of size to give a clearance of not less than 1½ in. and the recesses shall be formed to prevent lodgment of dirt.

9. **Anchor Bolts:** Anchor bolts shall be provided in foundations for lever stands to match the bolt holes provided for securing the stands, and they shall extend into the concrete not less than 15 in.

10. **Anchorage for Floating Levers:** Floating levers, viz., a lever exerting an upward pull at its fulcrum, shall be anchored to the foundation to resist not less than twice the uplift produced by a train of capacity cars passing over the live rails.

11. **Deck Beam Supports:** Inverted T-rails, or bearings of steel, shall be set in the side walls of the pit with the center of bearings of the beams not less than 6 in. from the inside face of the walls, but such bearings shall not be fastened to transverse beams.

12. **Beam Foundation:** The pillars supporting the beam shelf shall rest upon a reinforced concrete floor, steel beams or reinforced concrete beams, but the pillars and supporting beams, if used, shall be independent of the scale house floor if of timber construction. When it is necessary to install the scale beam in any building other than a regulation scale house, the pillar supports shall rest on foundations independent of the building unless the foundation of the building is free from vibrations and settlement.

Section XXII—SCALE BEAM HOUSE

1. **Design:** The minimum inside width of the scale house shall be 4 ft., and the minimum length shall be sufficient to allow the installation therein of a full-sized beam shelf and regulation beam of proper capacity for the scale, and self-recording attachment if used. It shall be provided with a bay window, or front and end windows, located with their sills about on a level with the top of the beam shelf, and of sufficient size to give the weigher a clear and unobstructed view of the scale deck and approaching cars so that he can read the car numbers and stenciled light weights when he is weighing. The windows shall be glazed with clear glass, or clear wire glass, free from bubbles or other imperfections.

2. **Clearances:** The lateral clearance between the scale house and the center of any track shall be not less than 7 ft. 6 in., or greater if required by law or by the railroad. A clearance of not less than 1 in. shall be provided between the inside of the scale house and beam supports and shelf.

3. **Ventilation:** Where a scale beam house is not provided with artificial heat a ventilator in the roof shall be provided.

Section XXIII—SETTING OF THE SCALE

1. **Fastening of Stands:** After alining the stands, large washers shall be applied to the anchor bolts and the nuts brought down tight. The anchor bolt holes in the castings shall be filled with cement, sulphur or other suitable material.

2. **Alinement:** All levers shall be level and connections plumb throughout the scale.

Section XXIV—SCALE WEIGH-BRIDGES

1. **Type of Girders:** In scales of more than two sections, weigh-bridge girders may be either of the continuous type or the non-continuous type, but non-continuous girders of such design of joints over centers of bearings as will admit of flexure vertically without derangement of sections are recommended.

2. **Steel Specifications:** Structural steel work shall conform to the specifications of the A. R. E. A.

3. **Size and Strength:** The following table of scale capacities and weigh-bridge girders gives the required sizes for weigh-bridge girders. This table is based on a representative car having two axle trucks 22 ft. from center to center, truck axles 5 ft. 6 in. center to center and 12 ft. center to center of adjacent end trucks of coupled cars.

4. **Bracing:** Each weigh-bridge span shall be designed for a lateral force of 200 lb. per linear foot plus

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4 per cent of the sectional capacity of the scale, applied at the top of the live rail and uniformly distributed.

(a) **Diagonal Bracing:** Diagonal bracing shall consist of not less than 3 in. by 3 in. by ⅜ in. angles and not less than 3 diagonals per span shall be used, or the equivalent of this bracing shall be employed.

(b) **Transverse Bracing:** To carry the lateral load to the knife edges of the main levers, each span shall be provided at its ends with a transverse bracing, of which the section modulus shall be not less than that determined by the formula:

Scale Capacities and Weigh-Bridge Girders

Lgh. of Sc'le C. to C. End Secs.	Span C. to C. of Secs.	Main Lever Cpty.	Dead Load Main Lever Reactn.	Live Load Main Lever Reactn.	Bureau of Standards Representative Car			Dead Load Mmt. 1 Grdr.	Reqd. Sec. Mod'l's	Alternative Girder Sections					
										Bethlehem Girder Beam		Double I-Beams		Single I-Beams	
					Wheel Load	Car Load	L. Load Moment 1 Girder								
feet	feet	pounds	pounds	pounds	pounds	tons	in. lb. ÷ 1000	in. lb. ÷ 1000	f = 10000	Sizes	Sec. Mod.	Sizes	Sec. Mod.	Sizes	Sec. Mod.
60 TON SECTIONAL CAPACITY															
45	15	60,000	3,750	56,250	23,440	93.76	1,476.7	84.4	156.1	18"x92#	176.8	.....	.....	1-24"x80#	178.9
48	16	60,000	4,000	56,000	22,400	89.60	1,612.8	96.0	170.9	18"x92#	176.8	.....	.....	1-24"x80#	178.9
50	**16.67**	**60,000**	**4,170**	**55,830**	**21,810**	**87.24**	**1,704.5**	**104.3**	**180.9**	**18"x92#**	**176.8**	.....	.....	**1-24"x90#**	**186.5**
51	17	60,000	4,250	55,750	21,540	86.16	1,744.7	108.4	185.3	18"x92#	176.8	.....	.....	1-24"x90#	186.5
54	18	60,000	4,500	55,500	20,810	83.24	1,872.9	121.5	199.4	20"x112#	234.2	.....	.....	1-24"x100#	198.3
56	**18.67**	**60,000**	**4,670**	**55,330**	**20,390**	**81.56**	**1,960.4**	**130.8**	**209.1**	**20"x112#**	**234.2**	**2-20"x65#**	**234.0**	**1-24"x105#**	**234.3**
57	19	60,000	4,750	55,250	20,190	80.76	1,998.8	135.4	213.4	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
60	**20**	**60,000**	**5,000**	**55,000**	**19,640**	**78.56**	**2,121.1**	**150.0**	**227.1**	**20"x112#**	**234.2**	**2-20"x65#**	**234.0**	**1-24"x105#**	**234.3**
63	21	60,000	5,250	54,750	19,160	76.64	2,241.7	165.4	240.7	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
66	22	60,000	5,500	54,500	18,730	74.92	2,360.0	181.5	254.2	24"x120#	300.6	2-24"x80#	347.8	.....	.....
69	23	60,000	5,750	54,250	18,350	73.40	2,523.1	198.4	272.2	24"x120#	300.6	2-24"x80#	347.8	.....	.....
72	24	60,000	6,000	54,000	18,000	72.00	2,687.4	216.0	290.3	24"x120#	300.6	2-24"x80#	347.8	.....	.....
75 TON SECTIONAL CAPACITY															
45	15	75,000	3,750	71,250	29,690	118.76	1,870.5	84.4	195.5	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
48	16	75,000	4,000	71,000	28,400	113.60	2,044.8	96.0	214.1	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
50	**16.67**	**75,000**	**4,170**	**70,830**	**27,670**	**110.68**	**2,162.4**	**104.3**	**226.7**	**20"x112#**	**234.2**	**2-20"x65#**	**234.0**	**1-24"x105#**	**234.3**
51	17	75,000	4,250	70,750	27,340	109.36	2,214.5	108.4	232.3	20"x112#	234.2	2-20"x65#	234.0	1-24"x105#	234.3
54	18	75,000	4,500	70,500	26,440	105.76	2,379.6	121.5	250.1	24x"120#	300.6	2-24"x80#	347.8	.....	.....
56	**18.67**	**75,000**	**4,670**	**70,330**	**25,910**	**103.64**	**2,491.1**	**130.8**	**262.2**	**24x"120#**	**300.6**	**2-24"x80#**	**347.8**	.....	.....
57	19	75,000	4,750	70,250	25,670	102.68	2,541.3	135.4	267.7	24x"120#	300.6	2-24"x80#	347.8	.....	.....
60	**20**	**75,000**	**5,000**	**70,000**	**25,000**	**100.00**	**2,700.0**	**150.0**	**285.0**	**24x"120#**	**300.6**	**2-24"x80#**	**347.8**	.....	.....
63	21	75,000	5,250	69,750	24,410	97.64	2,856.0	165.4	302.1	24x"120#	300.6	2-24"x80#	347.8	.....	.....
66	22	75,000	5,500	69,500	23,890	95.56	3,010.1	181.5	319.2	24"x140#	350.1	2-24"x80#	347.8	.....	.....
69	23	75,000	5,750	69,250	23,420	93.68	3,220.3	198.4	341.9	24"x140#	350.1	2-24"x80#	347.8	.....	.....
72	24	75,000	6,000	69,000	23,000	92.00	3,433.9	216.0	365.0	24"x140#	350.1	2-24"x80#	347.8	.....	.....
100 TON SECTIONAL CAPACITY															
45	15	100,000	3,750	96,250	40,100	160.40	2,526.3	84.4	261.1	24x"120#	300.6	2-24"x80#	347.8	.....	.....
48	16	100,000	4,000	96,000	38,400	153.60	2,764.8	96.0	286.1	24"x120#	300.6	2-24"x80#	347.8	.....	.....
50	**16.67**	**100,000**	**4,170**	**95,830**	**37,440**	**149.76**	**2,925.9**	**104.3**	**303.0**	**24x"120#**	**300.6**	**2-24"x80#**	**347.8**	.....	.....
51	17	100,000	4,250	95,750	36,990	147.96	2,996.2	108.4	310.5	24x"120#	300.6	2-24"x80#	347.8	.....	.....
54	18	100,000	4,500	95,500	35,810	143.24	3,222.9	121.5	334.4	24"x140#	350.1	2-24"x80#	347.8	.....	.....
56	**18.67**	**100,000**	**4,670**	**95,330**	**35,120**	**140.48**	**3,376.6**	**130.8**	**350.7**	**24"x140#**	**350.1**	**2-24 x80#**	**347.8**	.....	.....
57	19	100,000	4,750	95,250	34,800	139.20	3,445.2	135.4	358.1	26"x150#	396.5	2-24"x100#	396.6	.....	.....
60	**20**	**100,000**	**5,000**	**95,000**	**33,930**	**135.72**	**3,664.4**	**150.0**	**381.4**	**26"x150#**	**396.5**	**2-24"x100#**	**396.6**	.....	.....
63	21	100,000	5,250	94,750	33,160	132.64	3,879.7	165.4	404.5	26"x150#	396.5	2-24"x100#	396.6	.....	.....
66	22	100,000	5,500	94,500	32,480	129.92	4,092.5	181.5	427.4	28"x165#	468.8	2-24"x105#	468.6	.....	.....
69	23	100,000	5,750	94,250	31,880	127.52	4,383.5	198.4	458.2	28"x165#	468.8	2-24"x105#	468.6	.....	.....
72	24	100,000	6,000	94,000	31,330	125.32	4,677.6	216.0	489.4	28"x165#	468.8	2-24"x105#	468.6	.....	.....

Beams in pairs to be spaced 12 in. C. to C.

$$S \text{ equals } \frac{1}{4} \frac{(0.04C \text{ plus } 200L)d}{10000}$$

Where:

S equals section modulus,

C equals sectional capacity in pounds,

L equals length of span in feet,

d equals distance in inches from knife edge of main lever to top of live rail, or to top flange of girder if ties are used or when pedestals are braced to resist tipping transversely to the girder.

Intermediate transverse bracing shall also be provided of a section not less than that used in the ends of the span.

(c) **Stiffeners:** Not less than one pair of stiffener angles, other than splicing angles, shall be provided over each bearing of the girders in each span of the weigh-bridge. The ends of these stiffeners shall be milled to fit the fillets of the girder flanges.

5. **Live Rail Pedestals:** The live rail shall be carried on metal pedestals, which shall be mounted on metal ties or directly on the weigh-bridge. It is recommended that, when practicable, the pedestals mounted directly on the girders be cast or fabricated in units of two, set lengthwise with the girder to prevent the tilting action of the stands, produced by the deflection of the rails under load, and that they be transversely braced. Where pedestals mounted directly on weigh-bridge girders are used they shall be so designed that they will transfer the specified lateral load to the weigh-bridge. Where cast pedestals make contact with the rail they shall have their tops machined to grade or parallel to the bottoms of the pedestals. The bottoms of the pedestals shall be machined or type metal shall be used to pour between the base and the surface on which it rests.

6. **Fabrication and Assembly:** In order to avoid distortion, each pair of weigh-bridge girders shall be fabricated complete with sway and lateral bracing in the shop under proper inspection where practicable; where this method is impracticable and where field assembly is necessary, each pair of girders shall be placed in proper alinement and the bracing then introduced and secured by bolts or rivets.

7. **Live Rails:**

(a) **Weight:** The weight and section of the live rails shall be the same as that of the dead rails. See Section XXVII.

(b) **Length:** Full length live and dead rails without splices are desirable where they can be secured, but in all cases new rails shall be used, and where splices are necessary they shall be accurately applied.

8. **Clearance Along Live Rails:** The clearance between the live rails or their pedestals and rigid deck shall be not less than 1½ in., and the openings shall be protected from the weather and dirt.

Section XXV—APPROACH RAILS

1. Positive means shall be provided to prevent creeping of the ends of approach rails, and to maintain a clearance which shall be not less than ¼ in. nor more than ¾ in. between the approach rails and the live rails

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unless some special means is employed to reduce impact when wheel loads pass from approach rails to live rails. The effects of rail creeping may be eliminated by the use of switch points and bent stock rails placed in the approach track in the same alinement and plane with the live rails; each switch point to be set with its squared end either next adjacent to the live rail on the scale, or with an intermediate rail between the switch point and the live rail, and securely anchored to the approach piers by means of bolts anchored therein.

Section XXVI—DECK

1. **Type:** The deck or platform shall be of the fixed type, except to meet special cases.

2. **Construction:** The material for the deck shall be either reinforced concrete, wooden planking, or metal plates covered to prevent slipping, and as impervious to water as practicable.

3. **Clearances:** The clearance between the bottom of the fixed deck beams or deck supports and the I-beams forming the weigh-bridge shall be not less than 2 in.

Section XXVII—DEAD RAILS AND DEAD RAIL BEAMS

1. **Dead Rails When Required:** Scales shall be installed with dead rails or relieving apparatus, except to meet special requirements.

2. **Weight of Rails:** The weight of rails when supported on floor beams spaced 2 ft. 6 in. center to center shall be not less than that given in table corresponding to the axle load; for greater spacing of the floor beams the weight of the rails shall be correspondingly increased.

Axle Load, lb.	Weight of Rail, lb.
50,000	80
55,000	85
60,000	85
65,000	90
70,000	100

3. **Transverse Beams Supporting Dead Rail:**

(a) **Structural Steel Work:**..Structural steel work shall conform to the specifications of the A. R. E. A.

(b) **Strength:** The following tables give the sizes and strengths required for the transverse floor beams for different axle loads and the stated assumptions:

ASSUMPTIONS: 11′-0″ c. to c. of bearings.
Dead rail offset 16″.
Floorbeams 2′-6″ c. to c.
75% of axle load carried by one beam.
Dead rails 4′-11″ c. to c.

	Live Ld.	Req'd Sec'n	Alternative Floorbeam Sections			
	Mots.in	Modull	Bethlehem Beams		I-Beams	
Axle Loads	1,000 In.Lbs.	f = 10,000	Sizes	Sec. Mod.	Sizes	Sec. Mod.
50,000	745.7	74.6	1-15″x54#	81.3	1-15″x60#	81.2
55,000	820.3	82.0	1-15″x54#	81.3	1-15″x60#	81.2
60,000	894.9	89.5	1-15″x73# Girder	117.8	1-15″x75#	92.2
65,000	969.5	96.9	1-15″x73# Girder	117.8	1-15″x80#	106.1
					or 2-15″x42#	117.8
70,000	1044.0	104.4	1-15″x73# Girder	117.8	1-15″x80#	106.1
					or 2-15″x42#	117.8
75,000	1118.6	111.9	1-15″x73# Girder	117.8	1-15″x90#	112.7
					or 2-15″x42#	117.8

ASSUMPTIONS: 11′-6″ c. to c. of bearings.
Dead rail offset 16″.
Floorbeams 2′-6″ c. to c.
75% of axle load carried by one beam.
Dead rails 4′-11″ c. to c.

	Live Ld.	Req'd Sec'n	Alternative Floorbeam Sections			
	Mots.in	Modull	Bethlehem Beams		I-Beams	
Axle Loads	1,000 In.Lbs.	f = 10,000	Sizes	Sec. Mod.	Sizes	Sec. Mod.
50,000	799.3	79.9	1-15″x54#	81.3	1-15″x60#	81.2
55,000	879.3	87.9	1-15″x64#	88.6	1-15″x70#	88.5
60,000	959.2	95.9	1-15″x73# Girder	117.8	1-15″x80#	95.8
					or 2-15″x42#	117.8
65,000	1039.1	103.9	1-15″x73# Girder	117.8	1-15″x80#	106.1
					or 2-15″x42#	117.8
70,000	1119.0	111.9	1-15″x73# Girder	117.8	1-15″x90#	112.7
					or 2-15″x42#	117.8
75,000	1199.0	119.9	1-15″x104# Girder	162.7	1-15″x100#	120.1
					or 2-15″x42#	117.8

Section XXVIII
WEATHER AND DIRT SHIELDS

1. **Weather Guards:** Substantial metal guards shall be provided to cover the openings between the live rails and the deck to exclude dirt, snow and rain. They shall be so designed and fastened in place that they will be secure, but may be easily removed for inspection or repairs.

2. **Dirt Shields:** Substantial metal shields shall be provided throughout the pit, over all scale bearings and connections, applied to the deck, structural steel, or scale parts to prevent water or dirt falling into them or the accumulation of dirt or ice at points where it would interfere with the action of scale parts.

Section XXIX
LIGHT, DRAINAGE, VENTILATION AND CLEANING

1. **Light:** Proper lighting of the scale weighing beam, scale house, scale deck and scale pit shall be provided:

2. **Drainage:** The scale pit should be kept free from water by adequate drainage.

3. **Ventilation:**

(a) **Requirement:** All scale pits shall be ventilated to meet the needs of each particular case, the object being to have the least possible amount of moist air in the pit to prevent rusting of scale parts and structural steel.

(b) **Automatic Natural Ventilation:** The following arrangement is recommended for securing natural ventilation:

An opening should be made to the pit at each corner to connect with flues which terminate near the bottom of the pit, and another opening without flues extending downward should be made into the pit at its top and near its center. With such an arrangement circulation will always tend to be set up by the air whenever the pit is warmer or more moist than the outside, and when the pit is cooler or drier than the outside, circulation will tend automatically to stop. When this is done circulation will be set up only when it will tend to dry the pit.

Section XXX
ENTRANCE TO SCALE PIT

1. **Location:** Entrance to scale pit for the purpose of inspection shall be through either the floor of the scale house or foundation wall, and shall be closed by a suitable door so fastened as to prevent entrance of unauthorized persons.

2. **Hatches in Deck:** If it is desired to have hatches or openings in the deck, except such as are provided for ventilation, they shall be securely fastened from the inside of the pit.

Section XXXI
PROTECTION FROM CORROSION

1. **Shop Painting:** When no shop inspection is provided the steel castings and structural steel shall be given one shop coat of boiled linseed oil only. Other parts shall be painted one shop coat of red lead paint. When shop inspection is provided, all parts of the scale mechanism and structural steel shall be given one coat of red lead paint after inspection. In riveted work surfaces coming in contact shall be given one coat of red lead paint before being riveted together. All parts inaccessible after erection shall be given a second shop coat of red lead paint.

2. **Field Painting:** Scales and structural steel work shall be cleaned and painted with one coat (and preferably two coats) of paint in the field before installation.

RULES FOR THE LOCATION, MAINTENANCE, OPERATION AND TESTING OF RAILROAD TRACK SCALES.

Section I
LOCATION

1. **General Conditions.** The proper location of track scales depends principally on the following conditions:

(a) **The volume of traffic to be weighed in comparison with that switched over the scales and not to be weighed.** The presence of the scale in a much used track is a source of increased cost of maintenance and diffi-

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culty in inspecting and testing as well as dangerous to trainmen. In general, in yards not operated by gravity, the scale should not be located in a main drilling lead unless the number of cars to be weighed exceeds 60 per cent of the total number of cars handled or unless the total number of movements over the main drilling lead is comparatively small.

(b) **Whether the scale is to be equipped with dead rail or relieving gear.** If practicable, scales should be located where dead rails may be used.

(c) **Whether a run around track will be installed for switching with a separate track for weighing.** Where spot weighing is done the run around track is desirable. If cars are to be weighed as classified, the weighing track need be only long enough to clear the dead rail switches. If cars are to be weighed in solid cuts, the weighing track should be long enough to hold a cut of cars to be weighed, both before and after being weighed, in order not to block operation of other tracks while weighing is being done. The weighing track may be located alongside of the drilling track, alongside of the ladder track or on an outer yard track.

(d) **Whether cars are to be weighed spotted or in motion.** If cars are to be weighed in motion the scale must be on a grade in the drilling track at the head of the classification yard.

(e) **The cost of extra switching when the scale is not located on the lead to the classification tracks.** Ordinarily the cost of the extra switching may be ignored when the integrity of the weights would be affected.

(f) **The cost of maintenance when the scale is located on the lead to the classification tracks and only a small proportion of the cars are to be weighed.**

(g) **The necessity for quick dispatch of cars that are weighed.**

2. **Position of Live and Dead Rails:** Live rails should be on the offset line and the dead rails straight unless a large portion of the cars are to be weighed. For motion weighing the offset should be divided, unless the resistance is equalized by means of a spring switch.

3. **Grade for Motion Weighing:**

(a) **Runoff Grade:** When the scale is located on the lead to the classification tracks in a hump yard it shall be at such an elevation that the cars will run by gravity as far as desired into the classification yard with a maximum speed of four (4) miles per hour over the scale.

(b) **Approach Grade:** The distance and grade from the apex of the hump to the scale should be such that the speed of free running cars will not exceed 4 miles per hour on the scale without brake application; and such that cars can be so spaced and controlled that the weighing period of three seconds will not be reduced.

(c) **Grade of Live Rails:** Scales to be used for motion weighing should be constructed with the scale rails on a gradient not greater than one per cent. The weighing mechanism must in all cases be installed on a level plane, with supports introduced to fix weighing rails on the desired gradient.

(d) **Grade for Weighing Cuts of Cars:** The grade of the track for at least one car length in each direction from the scale should be the same as the grade over the scale. Where it is the practice for one car rider to take several cars together into a classification track, the same grade as on the scale should be maintained for at least 100 and preferably 200 ft. beyond the scale so that cars may be stopped easily by the car rider and so that the following cars will not cause excessive impact when striking the cars ahead. This should occur not less than one car length from the scale.

4. **Runoff Grade for Spot Weighing:** When a scale is installed not in connection with a hump, it is desirable that it be high enough to permit cars to run away from the scale by gravity after being weighed.

Section II
MAINTENANCE AND OPERATION

1. **Numbering Scales:** All track scales should be numbered and referred to by number and location.

2. **Scale Shop:** Extensive repairs to scales, such as the renewal or the sharpening of pivots, should be made in a properly appointed shop.

3. **Cleaning:** When scales are in service regularly, scale parts, substructure and foundations should be cleaned at least twice a month, and when exposed to the elements, or otherwise so located that they are liable to become clogged with ice or dirt, should be cleaned oftener.

4. **Rust Preventive for Pivot and Bearing Steels:** The best rust preventive obtainable should be applied to pivot and bearing steels, but it should be so applied as not to interfere with the proper working of the scale.

5. **Removal of Ice:** If ice obstructs the action of the scale, salt should not be used to melt it; artificial heat should be used.

6. **Standing of Equipment Prohibited:** Equipment should not be allowed to stand on the scale, except when being weighed.

7. **Restrictions to Use of Live Rails:** Engines or similar heavy equipment should not be passed over the live rails, except on authority of the department having supervision over the installation and maintenance of scales. The unnecessary passing of cars over the live rails should be prohibited. Weighed cars which have passed beyond the dead rail switch must not be returned over the live rails. The dead rail switches should be set for the dead rail track except when cars are being weighed.

8. **Cars Restricted to Live Rails or Dead Rails Only.** Cars on the live rails must not be moved by cars or engines on the dead rails or vice versa. Cars must not be moved over the scale with one truck on the live rails and another truck on the dead rails.

9. **Use of Sand and Injector by Enginemen Prohibited:** Enginemen must not apply sand or use the injector when on the scale. The slipping of engine drivers on either live or dead rails is injurious to the structure and should be avoided.

10. **Weigh-beam:** The weigh-beam should be balanced before the scale is used. When not in use it should be secured by the beam catch and with the poise set at the highest graduation.

11. **Stopping Cars on Scales:** Cars should not be stopped on the scale by impact, by the sudden application of brakes or by throwing obstructions under the wheels. When pushing off the scale cars which have been stopped for weighing or otherwise, impact must not occur at a speed greater than two miles per hour. When necessary for any reason to run cars over the live rails, the speed must not exceed four miles per hour.

12. **Automatic Weighing and Recording:** Where automatic weighing and recording devices are used it is absolutely necessary that both the scale and the automatic devices be in first-class condition, with properly maintained approach track, and cars must be run at a slow rate of speed with particular attention to steadiness of motion which is essential to obtaining best results.

13. **Locking Scale Houses:** Scale houses and beam boxes must be kept locked when not being used.

14. **Inspection by Weighmaster:** The weighmaster should familiarize himself with the construction of the scale and make inspections at such intervals as are necessary to determine whether or not the scale is in proper working condition. The weighmaster and anyone appointed to inspect and clean the scale should be properly instructed, and it is desirable that they be present with the scale inspector when the scale is tested.

15. **Painting:** The scale mechanism and structural steel should be painted often enough to prevent corrosion.

Section III
TESTING

1. **Tests with Single Test Cars:** Track scales in regular car weighing service should be tested at least every three months with a test car weighing not less than 30,000 lb.

2. **Graduated Tests:** Scales when installed and periodically thereafter should be given a graduated test with two or more tests loads up to the weight of the heaviest cars normally weighed. The frequency with which such graduated tests should be made depends on

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the design, capacity and method of installation of the scale used, the wear of scale pivots, and the amount of weighing performed.

3. **Weekly Tests:** A test should be made each week by weighing a heavily loaded freight car with as short a wheel base as is obtainable on each end and center of scale. When the scale is equipped with an automatic weighing attachment the car should, in addition to the above be, weighed spotted on the trip end of the scale and in motion with the automatic attachment connected. A report of these tests should be sent to the officer in charge of scales and weighing.

4. **Daily Tests:** In addition to the above, a daily test should also be made on each scale equipped with an automatic attachment, by weighing a car spotted on the trip end of the scale with the beam, also in motion with the automatic attachment connected. A book record of this and other tests should be kept by the weighmaster.

5. **Adjustment:** Track scales should be kept in the closest possible adjustment, and a scale should be considered inaccurate when it cannot be adjusted, and such adjustment maintained to within two pounds to one thousand pounds, in excess or deficiency, when distributed test is made with two or more test loads. When only concentrated sectional tests are made, the maximum error for any position of the test load should not exceed three pounds to each one thousand pounds of test load used.

The sensibility reciprocal of a track scale should never be more than one hundred pounds.

NOTE:—No uniform plan can be outlined for adjusting track scales of the different types manufactured, but as an illustration of the method followed, a system is given which is in a general way applicable to the more common types of lever systems generally used.

Section IV
EQUIPMENT FOR TESTING

1. **Standard of Mass:** The standards of mass for testing scales should be derived from primary weights, verified by the U. S. bureau of standards, Washington, D. C., to within what is known as their "Class B Tolerance." Such weights can be obtained either direct or through scale manufacturers. The fifty pound secondary or working cast-iron weights, which are transported from place to place and used directly in testing scales, should be rectangular, and of such design as to facilitate stacking; they should be free from pockets, blow holes, etc., which are liable to catch and hold foreign matter. No adjusting cavity or cavities in the bottom of the weights should be permitted.

These weights should be properly painted, surfaces maintained in good condition, and be tested and adjusted in comparison with master-weights, which have been verified to within "Class C Tolerance." The working weights shall be adjusted to within twenty-five grains and maintained to within one hundred grains of their true values.

NOTE:—The standards for testing scales in the Republic of Mexico must be in accordance with the metric system standards and will be verified by a Federal scale inspector in accordance with the Federal laws.

2. **Even Arm Balance and Master Scales:** It is desirable for verifying or scaling test weights and test cars to have, in addition to standards of mass prescribed above:

(a) An accurate even arm balance of one hundred pounds capacity in each pan, sensitive when loaded to two grains.

(b) A master scale.

SCANTLING. A small timber beam less than 5 in. square in cross section. The term is also used to express the sectional dimensions of timber, as 2-in. by 4-in. scantling.

SCARF. A joint used in splicing two pieces of timber, to appear as one, usually along a general diagonal line, sometimes with joggles, sometimes keyed and sometimes with lap joints. The timbers are bolted through the scarfed surfaces, the bolts and nuts bearing metal straps or plates countersunk in opposite faces of the stick. See Joint (Architectural).

SCRATCH COAT (Plaster). The first coat of plaster which is roughened when fresh by scratching and scoring its surface to afford a bond for the second coat.

Although this coat is rough it is evenly applied to obtain a true plane surface for the succeeding coats of plaster.

SCREED. A long strip of plaster or a narrow bar of wood put on horizontally along a wall and brought to a true surface to guide workmen in judging the thickness of the plastering for the wide intervals between them.

SECTION HOUSE. A section foreman's dwelling, frequently built or furnished by the railway company with a view to housing the foreman and sometimes the section laborers, in a location convenient to their work on the track.

In sparsely settled districts section houses are indispensable, while even in more populous territory it is frequently advisable for the company to own them to avoid complications due to the foremen living at a distance from their work and the consequent delay in reaching them in emergencies such as night wrecks or washouts. A further advantage accrues when the section house affords room for the section laborers. In some cases the foremen of adjoining sections with their families and the members of their gangs are accommodated at one location at the junction of the sections, in a double house, usually supplemented by a barracks for single men. These quarters are rented at nominal rates or the accommodations are considered as a portion of the employees' pay, assuring them of permanent, suitable and convenient housing. Disadvantages sometimes urged are the isolation of some section houses from stores and schools, the inconvenience and expense of maintenance and the difficulty of obtaining good water and proper sanitation. Local conditions and the status of employees in some measure govern these special cases. The maintenance of way is usually benefited directly and indirectly when appropriate quarters for trackmen are owned and properly maintained by the railway company.

A section house, usually of the cottage type, is limited to two stories or less, and though frequently built within the limits of the right of way, is preferably set back from the tracks on a special adjacent plot of ground where it will not be an obstruction to enginemen's view of the tracks and where there is room for outbuildings. A primary consideration is a suitable supply of water for residential use; reasonable assurance that it is available, or may be obtained economically being a governing factor in selecting the location. The extent of the building depends on the number of persons to be accommodated, while the style is that of suitability for use. While ornamentation is not usual, a section house is a permanent facility and real money involves a fair grade of materials and workmanship which tends to minimize the expenditure for maintenance. If there is doubt as to the permanency of the location the building is usually constructed with a view

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to moving it on cars, the dimensions being restricted accordingly.

The foundation, which usually includes enough cellar room for a stock of provisions, is preferably of masonry, as a house on posts or pillars tends to sag between supports and deteriorates quickly, the floors are cold and any winter banking of earth, straw, etc., against boards about the outside in lieu of a foundation wall tends to decay the posts and sills. Selection of the materials for the building involves the service life expected and the investment as in other structures. Most section houses, especially in the middle and western states, are small frame structures, erected by employees of the company's building department, from standard plans, specifications and bills of materials, these being

Typical Section Foreman's House with Tool House at Right and Bunk House at Left

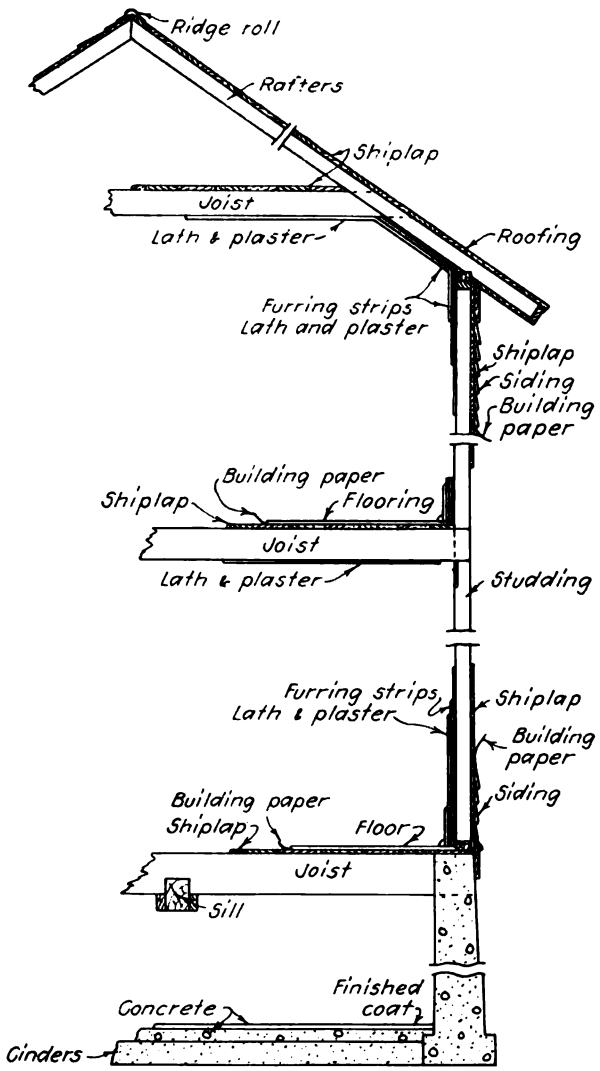

Diagram of a Section House Showing Parts

revised from time to time to meet the requirements of changing conditions in the methods and materials of the builder's trade. The present tendency is toward the betterment of housing conditions and increasing attention to convenience, permanence and pleasing appearance of section houses and their appurtenances. The construction depends largely on the climate, on the class of laborers employed, on the manner of housing unmarried men, etc. Some consideration is given the probabilities of changes of tenants and the variance in the number of persons in the families, provision being commonly made for the average number of five, with preferably an allowance above this number.

When standard plans are adhered to and the structure to be built or repaired is at a distance from division shops, as is usual, there is opportunity for economy in the framing or other preparatory construction of many items which may be shipped intact for erection, such as stairs, pantry fixtures, dimension materials cut to size, etc. In cold climates the ceilings are made low, storm windows are considered necessary, the chimneys are made to accommodate flues from all rooms, the kitchen is a room of the main structure and the house is located with particular attention to the prevailing winter winds and to ventilation. In southern latitudes the kitchen is preferably a separate structure connected with the house by means of a covered platform or "outside room"; while the ceilings are comparatively high, windows are higher, extending nearer to the floor, and screens for windows and doors are sometimes indispensable.

A rectangular structure with a plain gable roof, is the usual design, sometimes with three bedrooms on one side from front to back of the first floor and a dining room, kitchen and pantry on the opposite side with a stairway to the second story, which is all thrown into one large room to be reserved for laborers or divided into two or more rooms, a portion of the space being reserved for laborers. In some cases a special stairway leads to the laborers' quarters from which there is no direct access to other rooms in the house. Desirable features are clothes closets, hardwood floors and stair treads,

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a front porch, an outside roofed entrance to the rear door and insulated walls and ceilings. The porches help to protect and lengthen the service life of the doors, while the clothes closets conserve space in the rooms and eliminate the necessity for driving nails in the woodwork.

SECTION TOOL HOUSE. A small building used for storing the section motor car or hand car, maintenance of way tools and other equipment of a section gang.

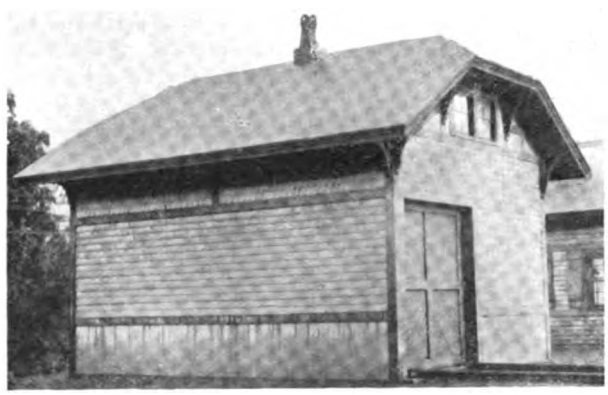
Each section gang is furnished with a tool house which is placed alongside the track for convenience in transferring the section car and tools. It is usually a one-room, unceiled gable-roofed structure, with siding or walls of boards and battens, preferably having a fireproof or fire-retardent roof covering of metal, ready roofing or the like. The tool house is located so that the double door faces the track, single sash windows usually being supplied in opposite walls to provide light. The door may be in the gable end or in the side, depending on the depth of ground available and on the floor space. A common design has a double door in the side near one end, the house being placed parallel with the track. It is usual in cold climates to provide a jacketed stove pipe in the roof as a stove is needed in winter.

The space in the loft under the roof is available to store spare tools such as rakes, scythes, etc. Shelves, lockers, tool racks and sometimes a short work bench are placed in the end not occupied by the car. Cinder or ballast floors are suitable and commonly used in these structures, although board floors are sometimes supplied.

The length of a tool house is sometimes doubled, a cross-partition dividing the building into two rooms, one of which is assigned to each of two gangs on adjoining sections.

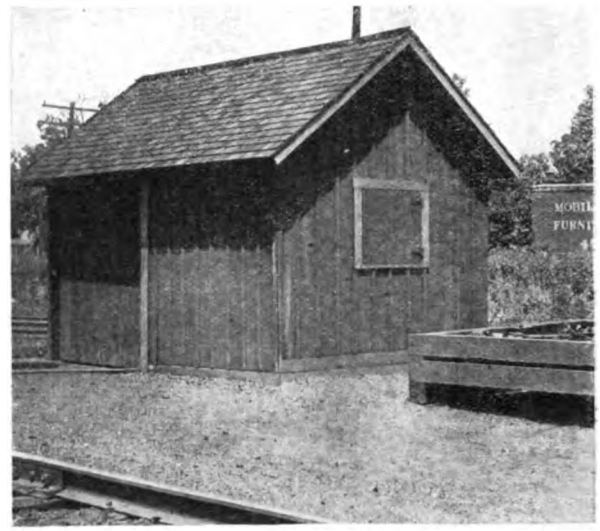
It is common practice to lay a runway from the house to the adjacent track on which the car may be run in and out of the house, and to lay a platform of crossing planks between the running rails on which to turn the car after it has reached the track. Sometimes wooden skids are used when light rails are not available to form the rails from the track into the tool house. These skids or rails are laid on a grade falling toward the door of the house to prevent the car from running toward the track.

SHEATHING. A rough covering for the skeleton frame of a structure on which a finished covering is to be fastened.



A Large Section Tool House

In framed buildings the outside sheathing is made of rough boards nailed horizontally to the studding. On the outside surface of the sheathing the insulating material, if any, is placed while the weather boarding drop siding or plain siding is nailed over all.



A Typical Section Tool House

SHED ROOF. A roof with a single inclined surface, the high side usually at the front and the low side at the rear of the building. Shed roofs are frequently used in one-story additions to small buildings such as section formen's dwellings and pump houses.

SHELF LEVER. A scale lever bolted to the under side of the scale beam shelf and hung to a link held by the bolt at the end of the short arm, while the vertical steelyard rod is suspended from its fulcrum and the long arm held up by the connecting rod depending from the fulcrum of the scale beam.

The shelf lever is a short bar only about half as long as the beam, wheras the main and extension levers are comparatively massive. Some scales do not have shelf levers, the steelyard rod connecting the transverse extension lever directly with the scale beam fulcrum. See Scale. Also Scale, Track. Also Extension Lever (Scale).

SHELTER SHED, BUTTERFLY TYPE. A type of shelter erected over platforms for protection from the weather with a central line of supports and a roof sloped towards the center for drainage. (A. R. E. A.)

In this type of roof there is no drip from the eaves, the water being carried from the central trough formed by the V-shaped sides to down pipes at or inside the central pillar. In cold climates the formation of ice from snow on the roof and in the down pipes is a disadvantage. See Roof.

SHELTER SHED, UMBRELLA TYPE. A type of structure erected over platforms for protection from the weather with a central line of supports and a roof sloped to the sides for drainage. (A. R. E. A.)

The true umbrella type is an arched roof, the straight line roof being a peaked type. The central

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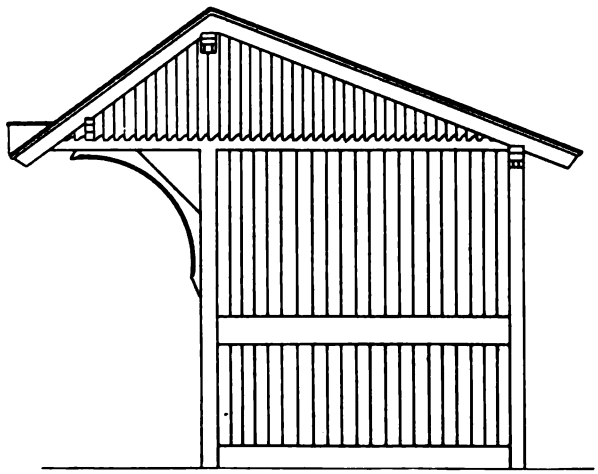
posts of either are knee braced to the roof timbers to stabilize the structure. See Roof.

SHINGLE. A thin rectangular piece of wood or sheet of metal, bituminous felt, asbestos, slate, or other weatherproof material suitable for a roof cov-



Sketch of a Shelter Shed

Butterfly Type Shelter Shed

ering when laid on a sloping surface as on a roof of moderate or steep pitch.

Shingles were originally made of wood and are still in general use for moderate sized buildings, the rectangular thin pieces being about 6 in. wide by 18 in. long packed in bundles of 1000.

While they make a dependable roof they are less permanent than the slate shingles largely used on extensive structures with steep sloped roofs. These are quarried and drilled with holes for fastenings and made in various dimensions.

Asbestos and Portland cement is a later development in fireproof shingles. These shingles are smooth pressed durable artificial boards, used on steep sloped roofs.

Ready roofing shingles consist of small sheets or shingles of the felt and bituminous binder which is a still more recent development in roofing material. They are fire resistant and are in common use. (See Page 722 and 734).

SHOP BUILDING. A structure designed and containing equipment for the construction and repair of locomotives, freight cars, and other railway equipment.

Locomotive shops for heavy repairs include blacksmith shops, boiler shops and machine shops where wheels are turned, frames are welded, boilers fitted with flues, etc. These buildings are usually grouped for convenience, or sometimes two or more are combined under one roof as the blacksmith and boiler shops.

Shop buildings are preferably built with steel frames and brick, concrete, stone masonry or tile walls, or some combination of permanent materials. with as much light and ventilation from the roof and sides as is needed for efficiency and comfort. These buildings are usually unceiled one-story structures with gable roofs, solid floors, large windows, double, sliding or lift doors, some affording clearances for tracks on which cars and locomotives may be run into the building for repairs and through it when completed.

SHORE. A post or beam in compression used as a temporary support, usually in an oblique position as a prop.

Shores are frequently used in small tunnels or excavations to prevent the walls from falling inward.

SIDING (Building). The covering or material for covering the exterior walls of a frame building to form the finished surface, as distinguished from the sheathing on which the siding is nailed.

Two kinds of wooden siding are in general building use, plain and drop siding. Plain siding is commonly 3 in. to 6 in. wide and slightly wedge-shaped in thickness. It is laid with the overlapping edge downward to lap as desired. Drop siding has an ogee edge, is usually 6 in. wide and is lapped on the ogee to separate the surfaces at the line of water drip.

SIGNAL TOWER. A structure designed and fitted for the operation of signals and as a watch tower for the signalman in charge of the plant. See Tower, Signal. Signal Section.

SILL (Building). The bottom line of horizontal beams of a building, which extends around the structure on the top of the foundation wall.

The frame of a house is usually built on sills. The interior beams which extend between walls or are supported on posts are also called sills or intermediate sills.

SILL (Door). A beveled strip of hardwood about 4 in. wide placed on a floor extending between the door posts beneath an outside door and mortised or built into the door frame, to fill the crack beneath the door when closed.

The sill is beveled flatly and equally on both sides. the central flat surface being usually no wider than the beveled surfaces.

SKIRTING. The line of boards which form the base around the margin of the floor of a room, and which together with top and bottom moldings forms the finish which conceals the rough bottom edges of the plastering and the flooring.

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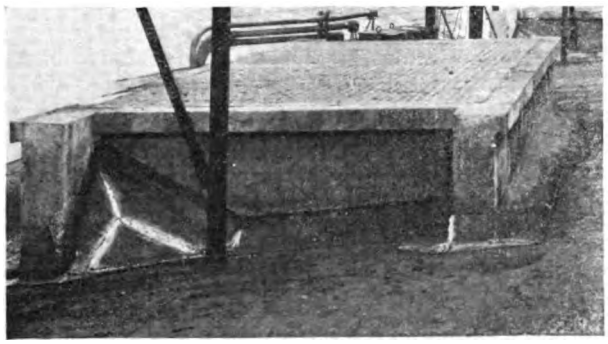


Skylight and Flashing

Skirting is commonly about 6 in. to 10 in. wide and presents a plain surface, relieved by the top and bottom moldings.

SKYLIGHT. A window placed in the roof of a building or a frame set with glass, either horizontal or in one or more inclined planes, for the purpose of lighting a passageway or a room below.

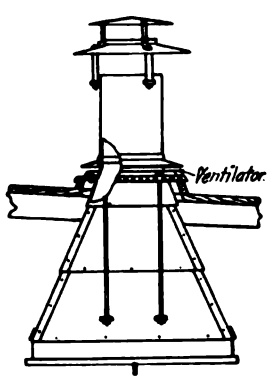
Skylights provide means of lighting buildings which are otherwise too dark owing to the proximity of other structures, etc., but are not readily kept water-tight unless carefully flashed.

SLEEPER. A piece of timber laid on the ground as a support for a superstructure, designed especially to carry the flooring of a temporary structure or other unimportant building.

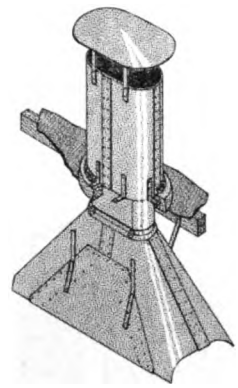
Cross ties of tracks are called sleepers except in America where the term is used to denote only a sill without artificial support.

SMOKE JACK. A ventilating appliance commonly placed in the roof of an engine house as a flue for taking out engine smoke and gases.

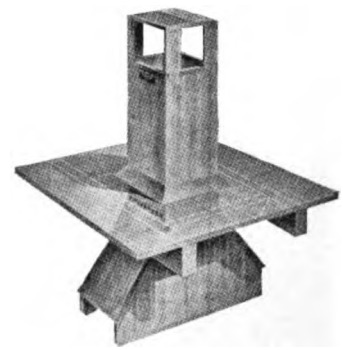
A smoke jack is considered a necessity for each locomotive stall and is placed above the location of the smoke stack of the locomotive when headed into the house. The above-roof appearance of a smoke jack is not unlike a large stove pipe with a flat ventilator cap. In cross section it is commonly round, oval or square, and may be of cast iron, pure iron, asbestos board, treated or sanded wood. Below the roof the smoke jack ends in a wide flare lengthwise the track, affording several feet of space from which fumes from the stack may be collected. The bottom of the flare is as low as possible, just clearing the locomotive stack. Special roof framing is usually provided to support the line of smoke jacks over the engine stalls.



Cast Iron Smoke Stack in Place
The Paul Dickinson Co., Inc.
(See Page 682)



Transite Smoke Jack
Johns-Manville, Inc.
(See Page 722)

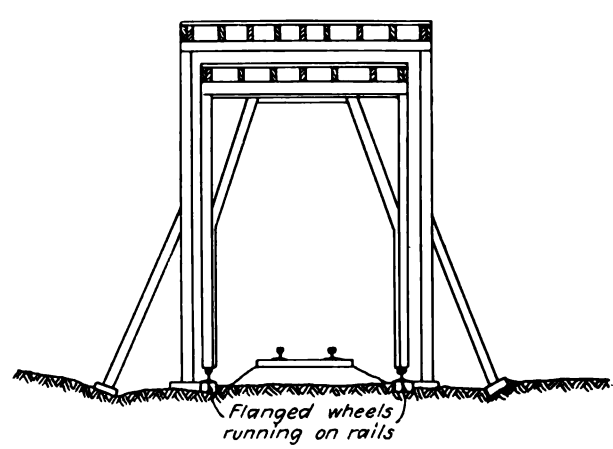


Wood Smoke Jack
The Smoke Jack Co.
(See Page 812)

Wooden smoke jacks are usually square in cross section, while asbestos jacks are rectangular or oval and iron jacks are round. The wooden jack is light, and when treated has an extended life if the fastenings are non-corrosive. Asbestos jacks are of medium weight and are put together on the ground from separate shapes made to fit together, overlap, and to be fastened by nails protected with non-corrosive paste. Pure iron jacks are of medium weight, round or oval, and are corrosion resisting. Cast iron jacks are also long lived and corrosion resisting. Some jacks are provided with dampers which may be closed to reduce or cut off the draft when disused. All have collars with flanges or a similar roof aperture construction to protect the structure against danger from fire owing to sparks from the locomotive stacks. The roof construction includes thorough flashing and counter flashing to protect the aperture occupied by the smoke jack. See Engine House.

SNOW SHED. A roofed structure built over tracks to protect traffic against snow blockades.

Snow sheds are restricted to locations where snow encroaches seriously and cannot be handled with plows, etc., usually in side-hill cuts on mountain



Telescopic Wooden Snow Shed on Level Ground

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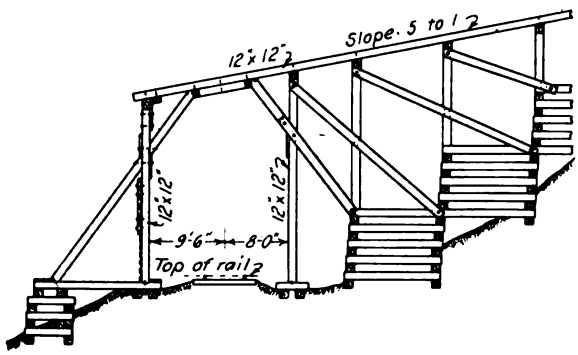
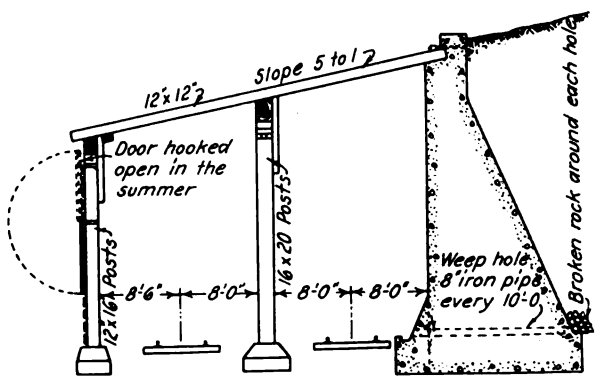
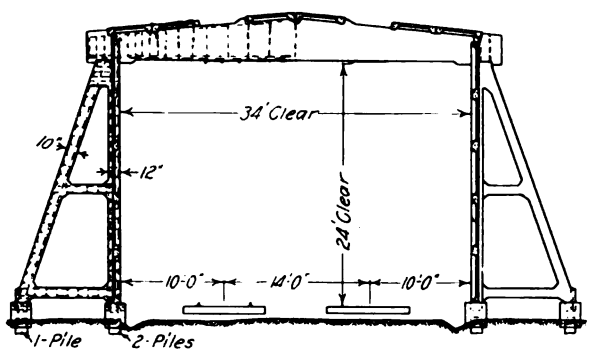
slopes where snow slides amounting to avalanches frequently bury the tracks. Hillside sheds are closed on the upper side and open or sometimes partially closed on the lower side of the tracks according to necessity. The roofs are designed to follow the slope of the ground above or to be slightly flatter to throw the snow clear of the roadbed. Another type, the level-fall shed, is sometimes built on level ground where heavy snowfalls periodically block unhoused tracks, or where drifts of snow and sand



Timber Snow Shed of Side Hill Construction



Timber Snow Shed with Concrete Back Wall for Side Hill Construction



Reinforced Concrete Snow Shed on Level Ground

fill the cuts with a mixture too hard to be moved by snow-handling equipment.

Snow sheds are commonly composed of heavy timbers strongly framed and braced; or they are sometimes made of reinforced concrete, with a view to permanency, to eliminating the fire hazard, and to minimizing maintenance. The minimum inside dimensions are such as to clear all equipment used.

In addition to the heavy cost of construction and danger of fires, the problems of ventilation and lighting are factors for consideration. Louvers afford roof ventilation and light is obtained through openings in the walls, while spaces are left between sections of sheds to limit possible fires as well as to provide ventilation; or telescoping sections about 100 ft. long are inserted at convenient intervals, these sections being mounted on wheels and rolled back inside the adjacent larger section in summer to afford a gap for fire protection. Flat roofs or roofs with one slope are used in preference to peak roofs as they are more readily relined in case the structure is crowded sidewise by the thrust of snow against it. The sheds are strongly side braced with timbers sloping from the base to the roof frame and are otherwise tied, sometimes into the hillside, to better withstand the concentrated loads and impact of snow.

SPOT WEIGHING. Weighing a car which is not coupled to other cars and which is brought to a stop on the weigh bridge live rails for the purpose. A car should be spotted in the middle of the weigh bridge and not close to one end.

STAGING. A workmen's temporary structure of posts and boards, forming a platform around the frame of a building for erecting purposes.

Staging is usually made of a line of posts about 3 ft. outside the wall while the cross pieces which hold the posts upright and connect them with the building frame form sills for loose boards laid on them as a floor. Staging is also sometimes suspended from cantilever beams and ropes or blocks and tackle from the top of the structure or from any level higher than the staging.

STATION. An establishment of traffic accommodations at a regular train stop, especially the passenger and freight house or houses and their appurtenances.

A station includes all the facilities provided for the accommodation of passengers, baggage, mail, express, freight and company materials, certain stations having additional facilities for coaling, sanding, watering, turning, housing and repairing locomotives and cars; as well as scales, stock pens, etc.

Stations are classified generally as passenger and freight stations. As regards their locations and relative importance, passenger stations are frequently spoken of as terminal, divisional, all-stop, local, wayside and flag stations. Some terminal stations are of less importance than other all-stop or even local stations on the same railway line. Division stations are frequently of importance only from the operating standpoint, while a way-side station may out-class them from the commercial viewpoint. Although there are many exceptions, the terminal of railways are usually in large cities where extensive station facilities than other all-stop stations, such as official quarters, despatchers' offices, refreshment rooms, equipment for icing, watering, cleaning and caring for coaches, etc.

All-stop stations are at places of enough importance to require that all trains stop to take on or discharge passengers. These are usually the larger

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cities along the line between terminals, frequently junction points with other railways. Local stations are those which are regular stops for only certain passenger trains, many of these stations being in cities of considerable importance, though more are in small towns.

The term wayside station is generally interpreted as indicating a stop for only mixed trains and the slower passenger trains, while flag stations are those at which only a limited number of trains stop and then only when flagged. A station may be a regular stop for a local train and a flag stop for a train of higher class, but a flag station is not a time card stop for any passenger train.

Although freight stations are subject to as many or more exceptions, they may be generally divided into terminal and local. A freight terminal is commonly considered as an important freight station served by stub tracks as distinguished from local stations situated alongside the main tracks and usually served by way freight trains. Many of these local freight stations have stub tracks but are commonly situated where a double end siding extends in front of them. See Station, Passenger. Also Freight House.

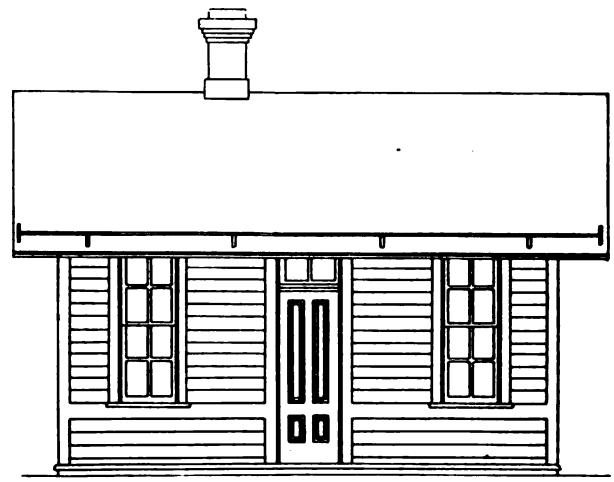
STATION, COMBINATION. A station designed for the handling of both passenger and freight traffic under one roof.

The necessity for such a station arises usually during a transition period in the growth of a town when the freight business has grown from less to equal or greater importance than the passenger traffic. The addition of a freight warehouse and platform to the office end of the local passenger or flag station alters it to a combination station and places the agent and his employees where they can most readily handle the general business. The freight portion requires a platform at car floor level and a wagon road or paved area accessible from a road and from the warehouse or platform for transferring freight.

A rather common arrangement is a siding and car level platform back of the station and a paved area at the warehouse end. The warehouse is sometimes partitioned at the office end to provide a small room for baggage and a "warm" room for perishable goods and express. The warehouse doors for freight are preferably placed at car length intervals, while the freight platform is roofed and low enough to clear the bottoms of refrigerator car doors. The warehouse commonly contains a dormant scale built into the structure for weighing l. c. l. freight. The passenger portion of the structure does not differ materially from other passenger stations excepting in the location of the baggage and express rooms in the freight warehouse. See Station, Passenger. Also Station.

STATION, FLAG. A station of minor importance where only a limited number of trains stop, and then only on display of a stop signal.

The passenger business being limited, as well as the freight business if any, the building or buildings are commonly not extensive nor elaborate. If an agent is in attendance there may be telegraph connections all or only a part of the time during the day and usually none at night. The flag station is preferably placed adjacent to the main track, so



Sketch of a Typical Flag Station

that passengers will not be obliged to cross other tracks to get to and from the trains. See Station, Passenger.

STATION, LOCAL. Any station other than a terminal which is a scheduled regular stop for passenger trains.

This class includes most of the stations of a railway system. The facilities are enlarged as demands increase, some local stations being larger and more important than many small terminals, while others are little more than flag stations, although a town of sufficient importance to have separate passenger and freight houses usually creates enough business for fair sized railway buildings. An insistent tendency on the part of the populace of small, growing towns is to want the local passenger station to abut on the main business street. This is usually a poor location as the street must be kept open across all tracks and trains stopping block the street traffic in both directions. If possible the location of any passenger station ground should be such that no street crossings over tracks are required for at least a train length or more from the station in either direction. See Station, Passenger.

STATION, PASSENGER. An assemblage of facilities for the accommodation of passenger traffic. (A. R. E. A.)

This term in its broadest sense includes the buildings, tracks, land and all appurtenances devoted to passenger traffic and included within the limits of a station ground. The structural interpretation, however, is limited to the building or buildings with their platforms, etc., in use for exclusively passenger purposes. The structure may be only an open shelter, or it may be a one-room building, a one-story wayside station with a single waiting room, or with a general waiting room, a women's room, office, baggage and express rooms and lavatories; or it may be a more extensive structure of one or more stories including also refreshment rooms, news stands, etc. Sometimes the express, baggage and heating facilities are in a building or buildings separate from the passenger station. The designs and extent of stations of different classes vary with the demands of business and other conditions, many local stations

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in large cities being more extensive and complete than terminal stations in smaller places.

Considerations governing the building of a passenger station include (1) the traffic demands, (2) the investment, (3) the probable rate and extent of business expansion, (4) the location of the site relative to the business center, the trackage, the grades and alinement, the topography of the ground, etc., and (5) other lines of transportation. The investment is usually considerable as compared with the buildings required for freight traffic, while the income on the money invested is often not so attractive. This condition often leads to limiting the appropriation below the amount necessary for the most permanent construction. The estimated service life of the structure requires consideration jointly with the probable rate of increase in business and the necessary facilities. As the latter cannot always be foreseen, it is advisable to build with a view to future enlargements.

While practical use is the primary consideration in railway building construction, the style and finish of a passenger station should correspond with the surroundings. Although architectural tastes vary, the present artistic tendency is toward the solid and substantial rather than the ornate in station buildings.

A majority of all passenger stations are between terminals, most of these being buildings at the level of and at one side of the main track or tracks.

Passenger stations at track level are designed with relatively wide frontage parallel with the main tracks and have platforms of ample dimensions to accommodate passengers entering and leaving trains, as well as for trucking of baggage, mail and express. The interior space of the building is divided with a view to placing the facilities in the sequence most convenient for the passenger who must first purchase a ticket and then check his baggage and afterwards probably wait for his train; or who, on detraining, wishes to get to the street by the shortest route, or desires to obtain a conveyance, check parcels, or claim his baggage without the confusion of mingling with outward bound passengers. A favorite arrangement of rooms in a side station at grade, especially if it has a considerable frontage, is a central lobby designed also as a wide passageway to and from trains, with waiting rooms for men and women on opposite sides, while the baggage and express are handled at the men's end of the building. It is usual to so arrange the entrances that persons entering or leaving the station will pass the men's room rather than the women's room. Many other arrangements are feasible and necessary with other types of buildings, as where a station is at a level above or below the tracks or between tracks, or where, as is occasionally imperative on account of heavy grades and curves, the entire passenger yard is on a spur track and trains must all either back in or out of the station.

Although designs vary widely, a large percentage of passenger stations are one-story buildings with widely overhanging gable roofs, being located at one side of the tracks at rail level. The materials in them are commonly such as are conveniently available, the frames being of steel or wood, with walls of stuccoed wood, brick, brick veneer, concrete block, hollow tile, etc., while the roof, designed with a minimum of valleys and flashings, is usually covered with some fire-resistant material, such as tile, slate, asbestos, concrete or prepared roofing shingles or sheets.

The foundations are preferably of permanent masonry, usually mass concrete, concrete block, brick or one or a combination of two or more of these materials. Hollow tile and plaster board are largely used for partitions, with expanded metal lath as a base for plaster coats. Floor surfaces are sometimes tile, more often hard wood and occasionally of concrete, although most concrete floors are covered with hard wood. The ceilings of stations are frequently made high to relieve the squatty appearance of a one-story structure with a wide overhanging roof. Sometimes high ceilings are designed to make room for high windows, which afford opportunity for good lighting and ventilation. Light colored woodwork, white or cream ceilings and indirect lighting are desirable details. Doors for passages are made wide and provided with automatic stops. Doors of express and baggage rooms should be made high and wide enough for loaded trucks.

While passenger stations may be classified as (1) passenger terminals, the range of structures under each class is such that the treatment must be general, admitting many exceptions. Passenger terminals frequently include headquarters offices as well as hotels, retail stores and other leased space used for other than railway purposes. Such structures are not usually directly in the charge of the building department forces of the railway and are therefore considered beyond the scope of this book. (2) junction or division point stations (3) local stations (4) flag stations and (5) open shelters.

Division points, while usually important stops for all passenger trains, are also frequently the terminals for some trains, while many junction points with other railways, where passengers detrain and wait for connections. Dining and sleeping car runs frequently terminate at these stations where the cars are cleaned and restocked. Such passenger stations are therefore more extensive than the average local station, usually including separate waiting rooms for men and women as well as a lobby or a general waiting room, a parcel room, a despatchers office and other division offices, lunch counter and dining rooms, and accommodations for the exchange of baggage, express and mail.

Where a railway has two or more main tracks, or where separate facilities are desirable at a crossing of two railway lines, twin stations are frequently utilized. In the first case, for suburban service especially, it is usual to have high-level platforms with the station on one side of the tracks and a shelter and covered platform opposite, with a connecting subway or an overhead bridge for crossing from one side of the tracks to the other.

This arrangement may serve multiple main tracks, an island platform with shelter being placed between each pair of tracks while the bridge or subway extends across all tracks with stairways leading to all platforms. Another arrangement where the tracks are above the street level as is frequently the case in cities where grades are separated, is to place the station building below the tracks with stairways to the island platforms and shelters serving the tracks above. Either double deck arrangement conserves

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space and is desirable also from the safety standpoint. The tracks are separately fenced and the entrances to stairways so arranged and designed as to minimize confusion.

Stations and platforms at car floor level are advantageous where passenger traffic is dense and especially where side door cars are used as in suburban service, but they are objectionable where snow drifts heavily onto the tracks as there is little room for its disposal.

The foundations required for a station building and its platforms at car floor level involve extra expense, while there are elements of danger and inconvenience not present in such structures built at track level.

Side stations at grade however are in most general use at local points. The track-side station building is commonly placed parallel with and facing the main tracks, an important feature being a bay window in the office which affords the operator a clear view of the tracks and of trains approaching from either direction.

An interior partitioning of a rectangular local station building recommended by the A. R. E. A., has a central general waiting room occupying the entire width of the building and 41 per cent of the total floor space, with a women's room and the lavatories at one end and the ticket office, baggage and express rooms at the opposite end. The only offset is for the operator's window. This arrangement of rooms and division of floor space affords a basis for the design of various sized station buildings, which may

Diagram of Passenger Station Showing Division of Floor Space, Recommended by the A. R. E. A.

differ widely in architectural treatment and still retain the proportions and the relative positions of rooms shown in the diagram, with the economies possible in roofing, heating, lighting and ventilating a building so arranged. The baggage and express rooms of a local passenger station are usually small in comparison with the waiting rooms, because incoming traffic is handled largely on trucks without going through the station building. To provide for emergencies when traffic is abnormal, roofed platforms frequently are built, sometimes connecting the passenger station with an express building at one end and a baggage room and heating plant at the other end.

The ticket office is centrally located and has a bay window for the operator facing the tracks, a counter with one or more ticket seller windows, a window exclusively for train orders, etc. The women's lavatory opens into the women's room only, the door being close to a partition wall or behind a screen. The men's room or smoking room has a door leading to the men's lavatory which usually has also an outside door, or in some cases the men's closet is detached from the station building. Where stations are above or below the track level, elevators for baggage, etc., as well as for passengers, are desirable. At busy stations it is important to avoid the handling of trucks along the length of platforms because of interference with passengers. Consequently, truck elevators are generally placed near each end of the platforms so as to be near baggage cars of trains headed in either direction. Some stations have separate platforms for baggage trucking, especially where such traffic is heavy.

Flag stations being points where there is only light local business, are smaller and simpler than the stations at regular train stops. Sometimes the building combines a passenger and freight station, and in some types the agent has living quarters in the second story, or one or two rooms in his dwelling may be devoted to station purposes. Where no agent is employed but shelter must be provided for passengers, a room in a section house is sometimes utilized and cared for by some member of the foreman's family. In any case the flag depot is usually alongside the track and is supplemented by a rail level platform. In case an agent is employed at the station, the track-side bay window in the station is as desirable as in more important stations. If there is a baggage room it is desirable to have it face the track with doors on the track side and the rear side, so that trunks may be handled through the room readily.

The style of the flag station will depend on the requirements and the importance of the locality. These stations are of plainest frame construction on many western lines, but of pleasing cottage designs on many eastern railways and on some western roads, the most permanent and artistic being located at suburban stops adjacent to the outlying residential districts of large cities. A large percentage of the flag stations of the country however are of plain frame construction. It is considered bad practice to place a flag station, or indeed any building which must be occupied by persons, on posts or pillars instead of an enclosed wall foundation, for there is danger of these footings settling unevenly and ruining the structure, while the loss of heat due to cold floors, etc., is uneconomical.

Passenger shelters are erected at flag stations where there are no regular attendants and no necessity for enclosed structures, as near private pleasure resorts where only a few passengers use the shelter for a brief period in summer. They are commonly shed or gable roofed frame structures with an open side toward the track, with unsheathed walls of siding and with a window at each end. A shelter is preferably located with the closed side in the direction of the prevailing wind and with a low platform about 10 ft. wide in front. A bench seat, usually constructed as a part of the building, extends around the three enclosed sides. Although inexpensive to build the shelter is comparatively expensive to maintain, the absence of an attendant being conducive to vandalism.

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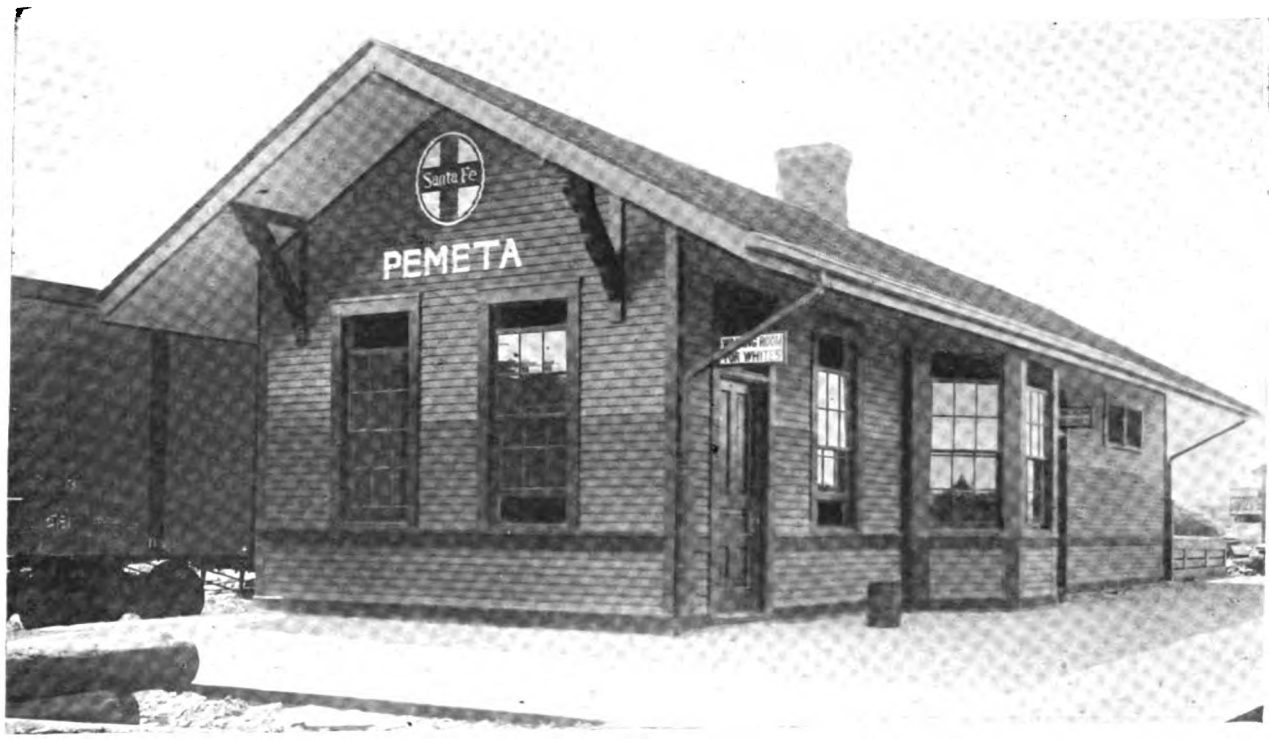
A Typical Small Frame Combination Station on the Atchison, Topeka & Santa Fe



A Typical Frame Combination Station of Moderate Size on the Atchison, Topeka & Santa Fe

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Combination Frame Station with Large Baggage and Freight Room

Frame Passenger Station with Offices above and Freight Station Annexed.

Common Form of Passenger Station with Division Offices Above—Illinois Central

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Small Brick Combination Station on the Buffalo, Rochester & Pittsburgh

Local Passenger Station of Brick Construction.

Small Brick Combination Station and Hip Roof Platform Shed on the Buffalo, Rochester & Pittsburgh

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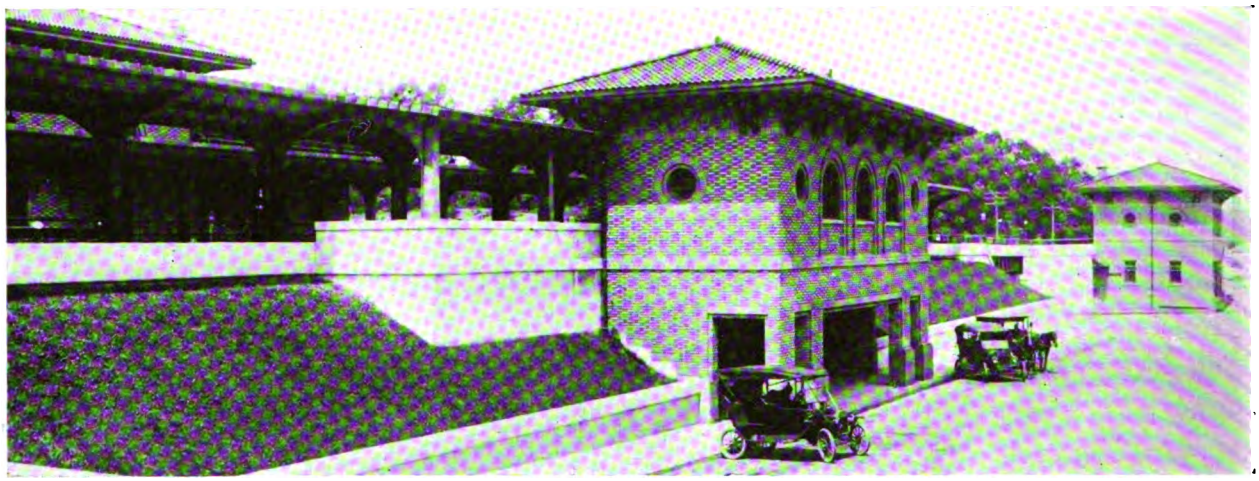
Brick Combination Station on the Delaware, Lackawanna & Western



An Elevated Brick Passenger Station with Entrance at Lower Street Level

Concrete Combination Station on the Delaware, Lackawanna & Western

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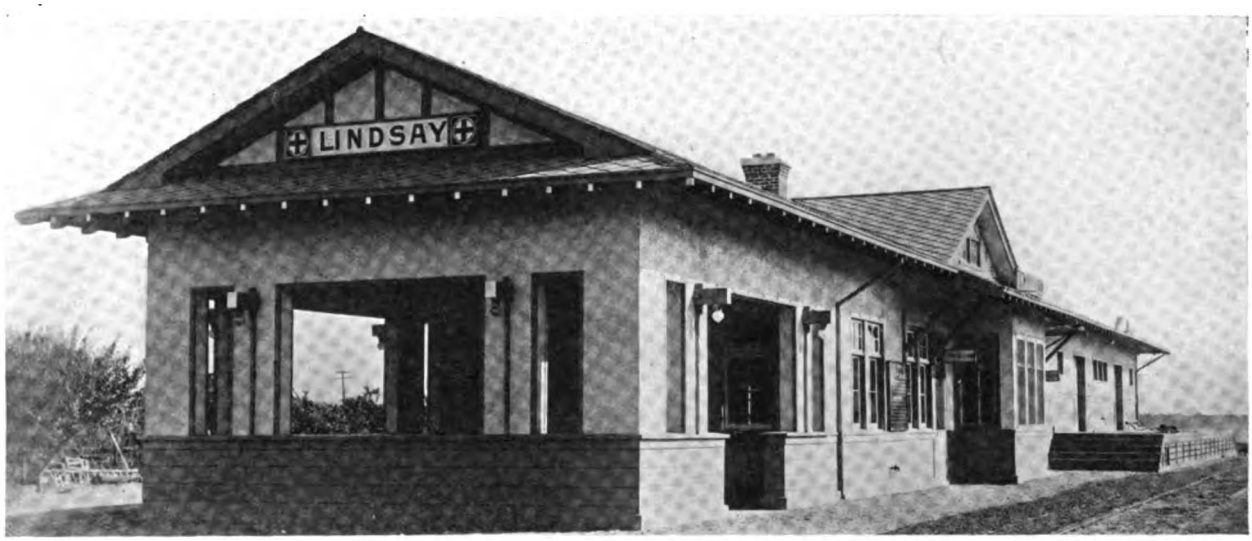
Brick Combination Station on the Atchison, Topeka & Santa Fe



Frame and Stucco Combination Station on the Atchison, Topeka & Santa Fe

Brick and Stucco Combination Station on the Illinois Central

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Brick Passenger Station on the Delaware, Lackawanna & Western

Concrete Passenger Station and General Office Building with Bush Train Shed in Foreground on the Delaware, Lackawanna & Western

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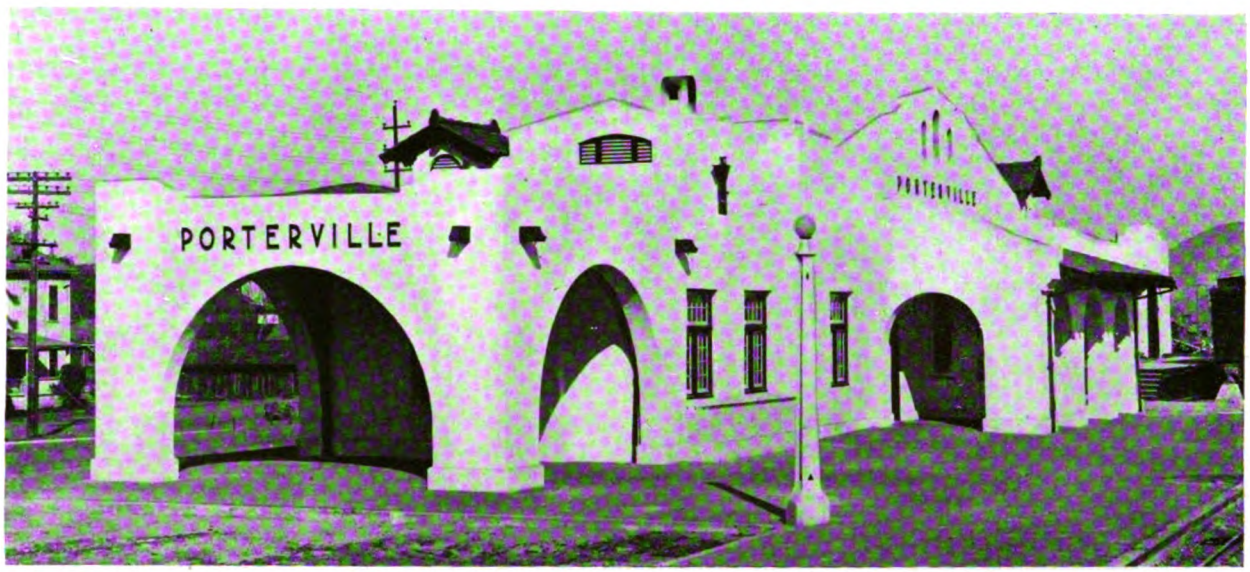
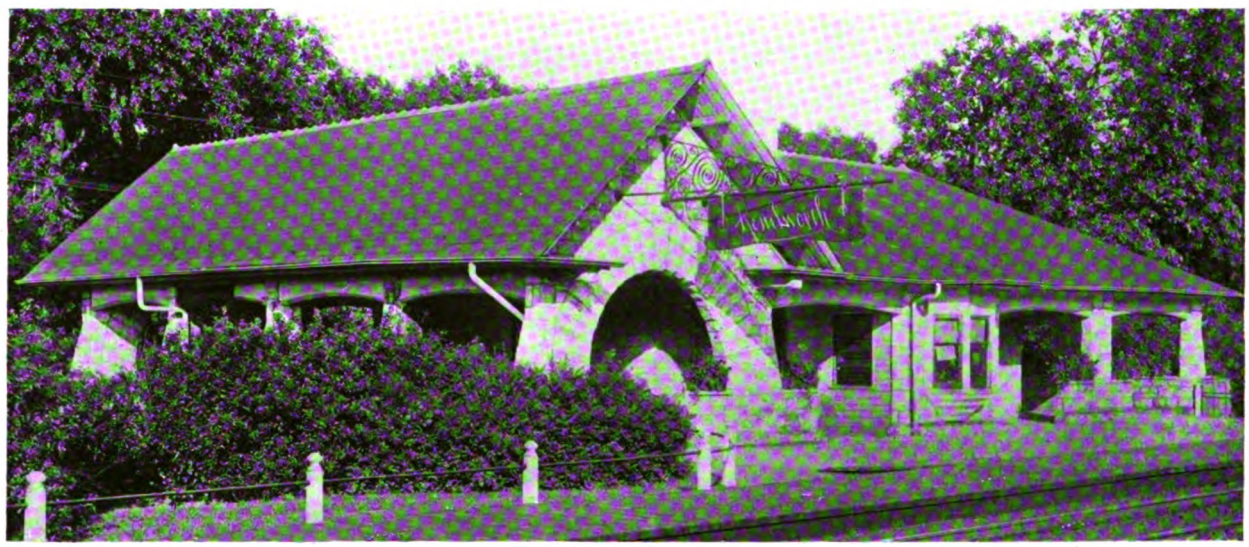
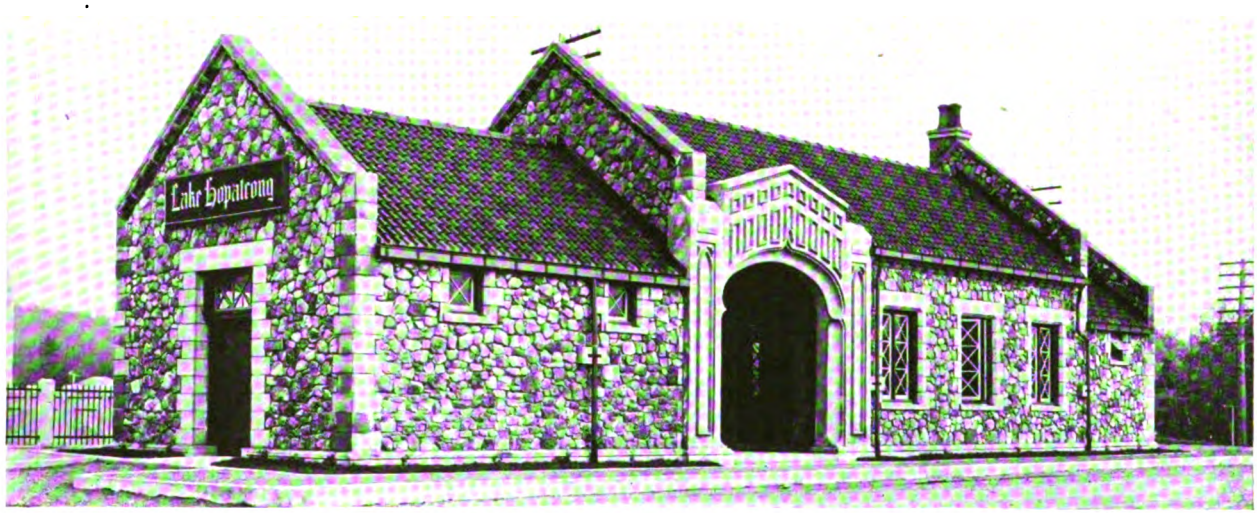


Mission Type Concrete Station on the Atchison, Topeka & Santa Fe



Range and Broken Range Masonry Station on the Chicago & Northwestern



Passenger Station of Rubble Masonry on the Delaware, Lackawanna & Western

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STEELYARD ROD. A vertical steel rod employed to transfer loads from the transverse extension lever of a scale to the shelf lever or the scale beam.

The steelyard rod of a track scale has a hook at each end and a turnbuckle in the middle. It passes through the floor of the weigh house, care being taken to maintain a clearance for it and to keep it exactly plumb with a view to accuracy in weighing. See Scale, Track.

STILE. One of the upright members of a piece of framing, into which the secondary members or rails are fitted, usually by a mortise and tenon joint, as in paneling or in a framed door. The stile to which the hinges of a door are attached is called the hanging stile while its mate is called the lock stile. See Rail, Building.

STOCK PEN. An enclosure for live stock which is awaiting shipment or delivery.

Stock pens are fenced spaces with connecting gates and with ramps leading to the service track at car floor level. Wagon scales are provided within a narrow enclosure which may be restricted to the area of the scale platform to weigh animals. Running water and facilities for watering and feeding stock are also provided.

Stock pen fences are designed to hold carloads of various kinds of animals in restricted spaces without danger of injury. They are usually board fences, open, but about 5 ft. high with posts 8 ft. to 10 ft. apart and made with heavy lumber and top boards. The gates are swinging or sliding wooden farm gates, made narrow to prevent stock from crowding or sometimes arranged to swing so as to form one side of an alley. Several pens with connecting alleys and gates are usually supplied to make it possible to separate carloads and kinds of stock.

STORM WINDOW. A sash placed outside of the window sash near the outer face of the casing, providing a protecting air space between the two sashes as a measure of insulation.

STRAP, STRUCTURAL. An iron plate with holes for bolts used for connecting two or more timbers, as in securing the timbers of a roof, or in a scarf joint.

While straps may be of any dimensions and may have any number of bolt holes, they commonly are sections of flat steel with a minimum of four holes to provide for two bolts on each side of the joint. See Scarf.

STRING BOARD. A board which supports any important part of a framework or structure, such as the board which covers the ends of the steps in a wooden structure and on which the treads and risers rest. There are usually not less than three parallel string boards in a stairway 4 ft. to 6 ft. wide.

STUD. A post used in partitions and outside wooden walls and to which laths and boards are nailed, usually 2 in. by 4 in. and 2 in. by 6 in. in sectional dimensions.

Studding is commonly doubled to form the ends of partition walls as at doorways and walls, or trebled at junctions of walls, in small frame houses.

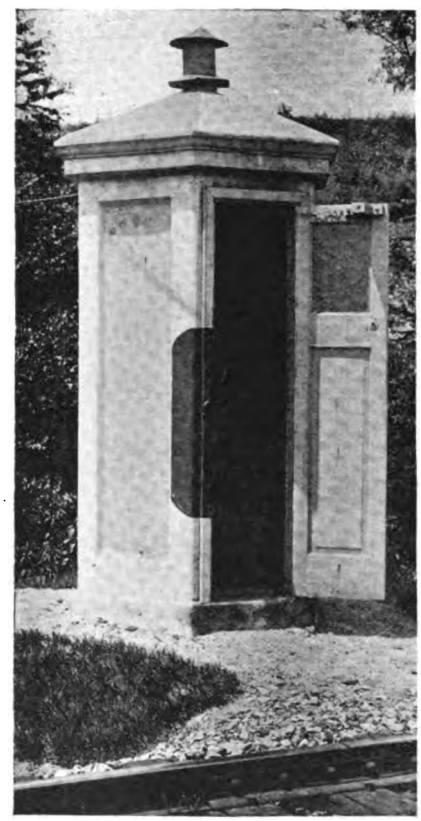
STUDDING. A small slender timber post used in framing the partitions and lighter portions of wooden buildings. Studding is commonly 2 in. by 4 in. or 3 in. by 6 in. It forms the skeleton of the frame work on which the wall is erected and to which the lath, plaster board or wall board, etc., is fastened.

T

TAIL TRIMMER. A trimmer designed to receive the ends of floor joists, such as is necessary around the brickwork of a chimney. The trimmer is set clear of the brickwork, parallel thereto and supported by other frame members.

TELEPHONE BOOTH. A one story building designed to enclose a wall telephone, and with enough floor space to afford standing room for persons using the telephone instrument.

Telephone booths are usually portable buildings and may be made of any building material, a suitable type is made of reinforced concrete, with a peak roof carrying a steel ventilator at the apex. The structure is usually hexagonal in horizontal cross section,



Concrete Telephone Booth

with a narrow door containing a glass sash in the upper panel and a lock to which employes have keys. The structures are of use for the transmission of orders, especially at outlying stations or in yards, on railways where the telephone is used for despatching trains.

THROAT. A channel or groove made on the underside of a string course, coping, etc., as a means of preventing water from running inward towards

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the wall; sometimes called a drip. The presence of the throat induces the accumulation of moisture at its outer edge, where the timber tends to decay quickly in consequence unless the piece is treated with preservative after manufacture.

TIE BEAM. The horizontal member of a roof truss extending usually from wall to wall, and into which the rafters are framed, its center being commonly kept from sagging by means of a king-post. Intermediate truss members or braces are frequently introduced to help support the tie beam in a long span. See King-Post.

TILE, BUILDING. A thin slab or plate of kiln-burnt clay, concrete pottery, slate or marble in general use as flooring or roofing. Some types are also used to line furnaces, smoke flues, wainscotings and fire places. They are variously formed and compounded, depending on the use in view.

Roofing tiles are either flat and laid to overlap, or curved and placed so as to overlap or designed to be united by interlocking. Floor tiles are flat and usually square or rectangular, as are also those used in grates and mantels. Furnace tiles are made to fit the periphery of the fire box, several curved sections commonly being required to line the circumference of a circular furnace. Smoke flue tiles, sometimes radial, are similarly used, although tubular tiles about 24 in. long and 8 in. to 12 in. square or larger, with rounded corners are frequently set one on the other to form the flue lining. All tiles used for interior work are commonly set in cement on the most solid foundations available. They are burnt hard and most styles are glazed. Being comparatively small units, they are not very difficult to replace, but, having no elasticity, they are easily cracked by heavy loads and should not be laid where sudden concentrated loading is expected. See Tile, Cement. Also Roofing. Also Flooring.

TILE, CEMENT. Rectangular tile made of fine reinforced concrete in thin slabs, commonly used to cover the purlins of a roof, eliminating the need of roof boards, or shingle sized roofing tile used as roof board covering. See Roof. Also Roofing Tile, Cement.

TOLERANCE. An allowance made for a small variation within the limits of reasonable accuracy, as in scales and scale parts.

Tolerances are specified in scale tests, lengths of levers, notches in the weigh beam, offsets of knife edges, the heights of lever stand pillars, etc.

TONGUE. A projection on the end or side of a board or timber to be inserted into a groove to make a joint.

Hard wood flooring is manufactured with tongued and grooved ends, the tongues and grooves being rectangular in section, of less dimensions than the flooring and centrally located in the end section of the pieces so that when the ends of two pieces are united the joint is hidden.

TRANSFER PLATFORM, FREIGHT. A platform approximately level with freight car floors used in transferring freight from car to car. (A. R. E. A.)

These structures are commonly wooden island platforms of considerable length and 8 ft. to 12 ft. wide with central posts supporting peaked roofs, and with steps or ramps or both at the ends. Some transfer platforms are without roofs but it is considered good practice to protect the freight from the weather to this extent during transfer.

TRAIN SHED. That portion of a terminal or other passenger station where travellers enter and leave trains.

Train sheds form parts of terminal and extensive passenger stations, covering the tracks and affording protection from the weather. Although many train sheds are built over through tracks, they are more frequently provided at stub-end terminals. The common arrangement includes a building long enough to provide track room to accommodate the entire length of a train, usually a number of parallel tracks with platforms between, beneath an extensive trussed roof sometimes with open channels over the track centers affording ample space for smoke to escape from locomotive stacks without filling the building, to the inconvenience of passengers.

Where conditions permit, baggage, mail and express are handled to and from the cars from floors above or below in elevators, etc., to prevent congestion on the platforms between the tracks. Train sheds are lighted from the sides and the roof as well as by means of artificial light.

TRANSOM. A movable window, usually rectangular, placed over a door to afford light and ventilation. A common form of transom consists of a single pane of glass mounted in a wood or metal sash which is either hinged at its upper or lower edge or axially pivoted to the sides of the door frame. Transoms are commonly designed to be raised and lowered when hinged or swung open, and shut when pivoted by means of a movable metal rod which is fastened on one side of the door frame with a spring catch to hold the transom shut when closed.

TRANSVERSE EXTENSION LEVER. The horizontal lever extending from a connection with the longitudinal extension levers to a point beneath the weigh house floor where it connects with a vertical rod transferring loads to the shelf beam. This lever is sometimes known as the fifth lever, or middle extension lever.

TREAD. The top of a step in a stair as distinguished from a riser; therefore in stair case design, the horizontal distance from one riser to the next.

Wooden stairways have bevel-edged treads which overhang the risers. Wooden treads are preferbly made of hard wood and frequently protected by means of metal strips about 4 in. to 6 in. wide, the strip extending the whole width of the stairway at the outer edge of the tread which is subject to the greatest wear.

TRIM. To fit up and finish, such as to frame a door opening in a wall.

The parts which impart a finished appearance to the building structure, hiding the rough ends of floor boards at the walls of a room, or the rough edges of boards in a door jamb, etc., are called trimming, or trim.

TRIMMER. A piece of timber inserted in a roof, a floor, or a wooden partition, etc., to support the ends of any of the rafters, joists or headers which are framed into it.

Trimmers and headers are used in openings in floors designed for staircases, chimneys and the like.

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When an opening comes at the angle of two walls the trimmers are doubled and the header is held between them.

TRIMMER ARCH. An arch built in front of a fireplace in the thickness of a floor between two trimmers, to support a hearth. The bottom of the arch starts from the chimney while the top presses against the header.

The trimmer arch is usually covered with a layer of concrete in which the tile or brick flooring is embedded.

V

VALLEY. The internal angle formed by the meeting of two roof slopes, as distinguished from the external angle formed by a hip or ridge.

Valleys require deep flashings to prevent moisture from finding its way through the roof, especially in view of the probability of the backing up of water due to ice and snow or debris in the down pipe inlet and eaves trough.

VENTILATE. See Ventilation. Also Ventilator, (General Section).

W

WAINSCOT. A wall finish of wood or wood substitute covering the bottom fourth of the face of a wall interior, and consisting of a series of panels dressed and matched siding, usually about 4 ft. above the floor and generally finished with a projecting molding cap and a ¼-round molding at the base. While some substitute materials are used as wainscoting, wooden panels of finely grained, knot-free oak, beach-wood and pine predominate.

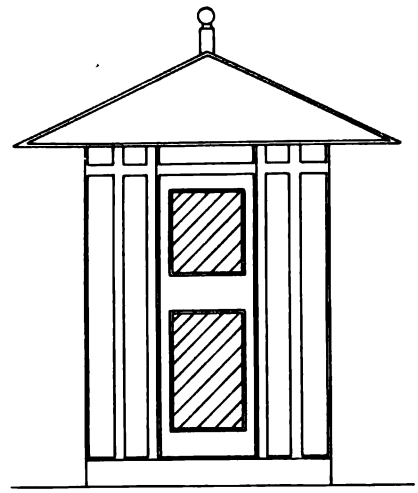
WALL PLATE. A horizontal timber placed in or on a masonry or brick wall or under the ends of girders, joists and other timbers to form the support for the roof of a building. The wall plate is made as wide as the ends of the uprights which it connects and on which it is supported. See Plate.

WARM ROOM (FREIGHT HOUSE). A special room for perishable freight, insulated and containing provisions for artificial heat.

A small room partitioned off with three interior walls and a low ceiling with the only door opening from the ware room, is preferably placed against the middle of the main partition separating the agents office from the freight wareroom in local stations. See Freight House.

WATCHMAN'S HOUSE. A small building with one room, used as a shelter for a watchman engaged in protecting traffic at a crossing or other location where there is danger of collisions or other conditions requiring his presence.

This class of structures ranges from 5 ft. to 8 ft. square, inside dimensions, and is built on sills with a door facing the tracks and single sash sideslide windows in the directions facing the traffic. They are usually movable frame structures but are also built of reinforced concrete, of metal, etc., frequently to standard plans and specifications. A hip roof is the common design, the over-hang being relatively wide while the roofing may be of any of the various coverings, preferably fire retardent or fire proof, ready roofing being widely used. The house is ceiled, floored and lined with dressed and matched lumber and a jacketed flue is provided in the roof for a stove pipe. The dimensions of the building are usually restricted on account of its location between tracks, or because it must be near an intersection where traffic from all directions may be



Sketch of Watchman's Frame House

observed, while the building presents no obstacle to the line of sight of enginemen or other travelers.

WATER TABLE. A slight beveled-edged projection from the outside face of the masonry of the wall of a building, generally placed at about the first floor level to drain water away from the foundation.

WEATHER BOARDING. The horizontally over-lapped boards which form the outside surfaces of wooden buildings.

Weather boarding may be of any suitable dimensions, some buildings having boards 10 in. wide, but the usual width is 4 in. to 6 in. The section may be plainly rectangular, but is usually slightly wedge shaped or with an ogee surface as in drop siding.

WEATHERING. A slight inclination given a horizontal surface to throw off water, as the top of a cornice, a window-sill, etc. Exposed surfaces of buildings are commonly protected in this manner, as flat wooden members decay rapidly owing to accumulations of moisture which tend to soak into the wood.

WICKET. A small door-opening in a larger door to accommodate one person at a time, as in an engine house.

The wicket is made in a lower panel of the larger door, the bottom being usually about 18 in. above the floor, the door usually opening outward.

WINDOW. An opening for the admission of light and sometimes of air into the interior of a building, the construction consisting of a frame and sash or casement, the sash being supplied with panes of glass. The term is usually limited to openings in approximately vertical surfaces such as walls.

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WING. A projection or extension of a building from the side of the main portion, usually at an angle of 90 deg. A wing adds floor space without complicating the architectural treatment of windows, doors, etc., but involves valleys in the roof connection.

WOOD, AIR SEASONED. Wood seasoned under ordinary atmospheric conditions, either sheltered or exposed, without any artificial source of heat.

Thoroughly air-seasoned wood, depending upon climatic conditions, contains from 10 per cent to 20 per cent of moisture, based on the oven-dry weight of the wood. The common method of air seasoning timber is to pile the sticks in open piles to admit air between them and to keep them so piled for several months if possible. Some authorities recommend 12 months seasoning while the average period is probably not more than 6 months, depending largely on the dimensions of the piece and the species of the timber. See Kiln Dried Wood.

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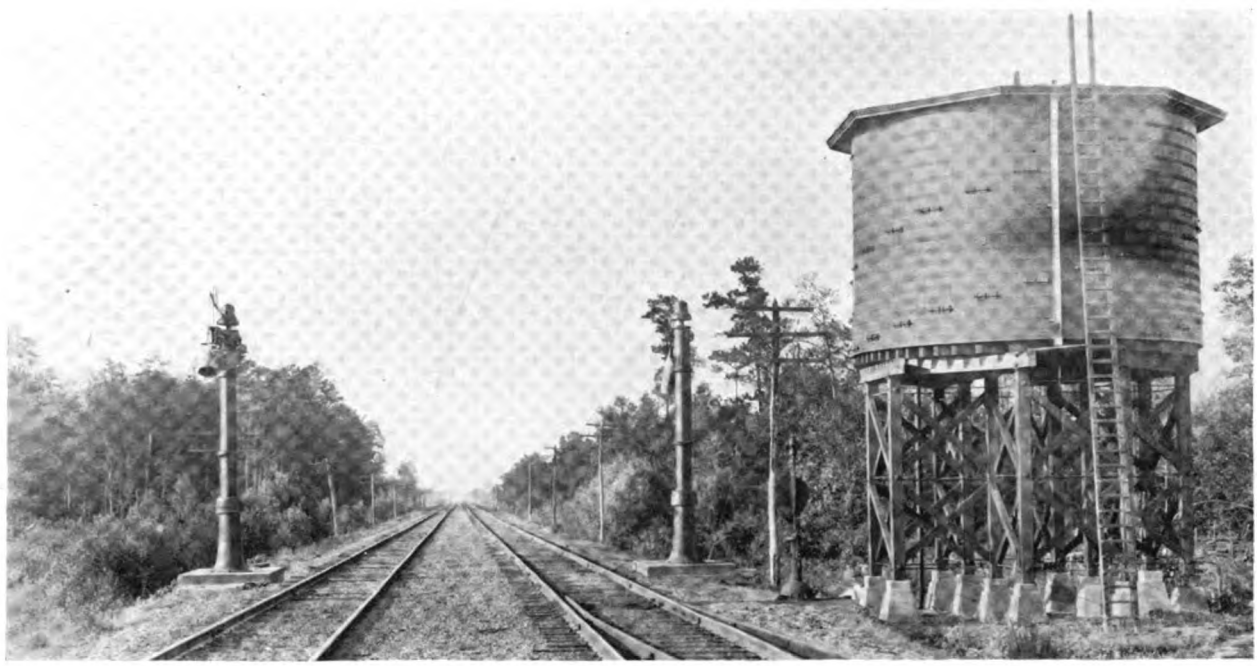
The
Water Service Section



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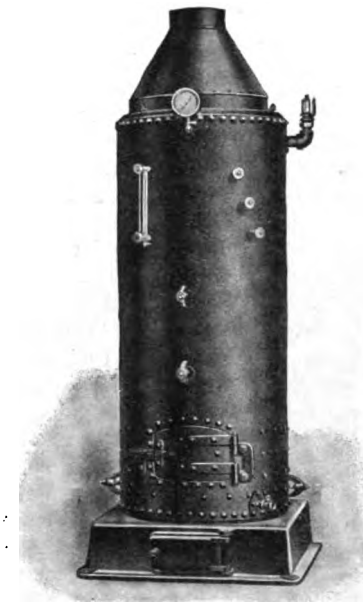
A

AIR LIFT. A simple and effective way of raising water by means of compressed air, which is forced down to the bottom of an air pipe placed inside the well casing, and then liberated to rise in the annular space between the walls of the two pipes, through the water with which it mixes and to which it imparts a buoyancy which causes it to rise.

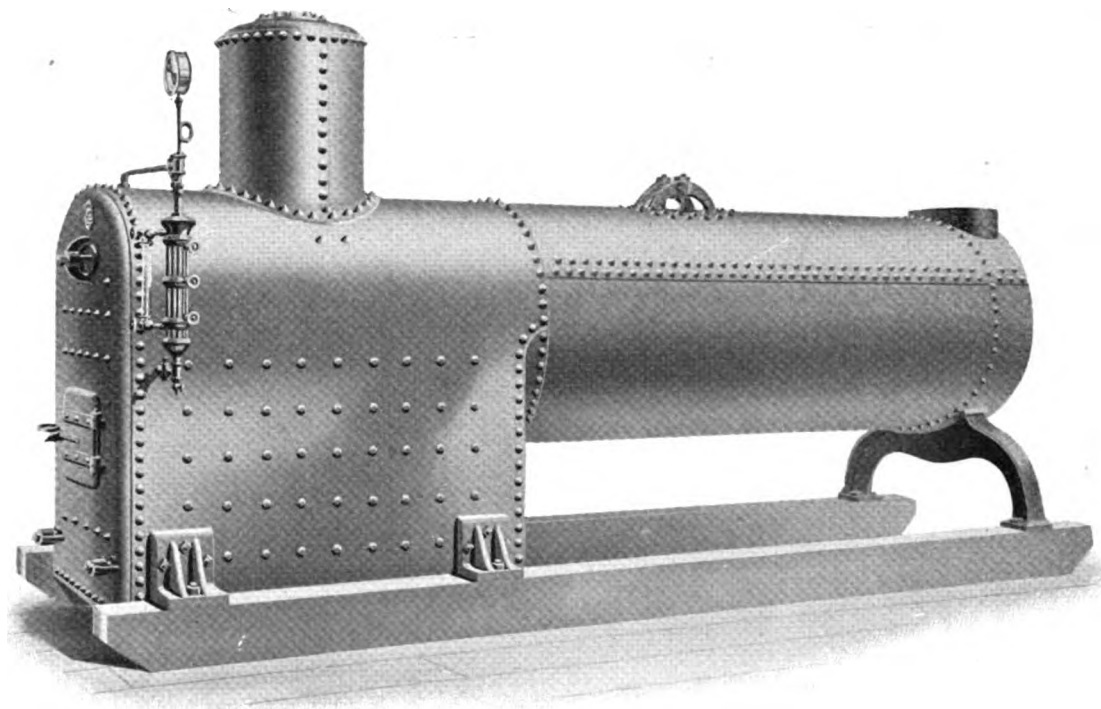
B

BLOW-OFF. The act of letting out water or steam from a tank or boiler to carry off sediment, or to reduce the concentration of foaming salts. The blow-off valve is located at the bottom where the precipitate collects. A suitable pipe is commonly attached to carry the sludge in the direction and to the distance required outside the tank.

BOILER (Locomotive Water Supply). A closed steel cylinder in which water is evaporated into steam by the application of flame and heated gases of combustion, for the generation of power. The various types may be classified as horizontal and vertical boilers, in which the water is contained within more or less cylindrical vessels traversed by tubes through which the flames and gases pass to impart their heat to the water; and water tube boilers, in which the water is contained within the tubes, the products of combustion circulating around them on courses determined by suitable baffle plates. The longitudinal tubes through which the water or products of combustion pass, according to the design, vary from 2 in. to 4 in. in diameter. Boilers of the horizontal type suitable for locomotive water stations vary from 3 ft. to 6 ft. in diameter and from 8 ft. to 18 ft. in length and have a rating of from 20 hp. to 100 hp., while those of the vertical type vary from 30 in. to 48 in. in diameter and from 80 in. to 128 in. in height, with horse-power varying from 10 to 45. They are either self-contained within a suitable metal casing or mounted in brickwork, or both. The three most common types are the vertical tubular, the locomotive type and the horizontal tubular boilers.



Vertical Boiler
The Mead-Morrison Manufacturing Co.



Locomotive Type Boiler
The Murray Iron Works

Vertical tubular boilers are of two kinds, the submerged tube and the full length tube. They differ in that the upper tube sheet of the submerged type and the entire length of the tubes are below the water line; while the upper tube head of the full length

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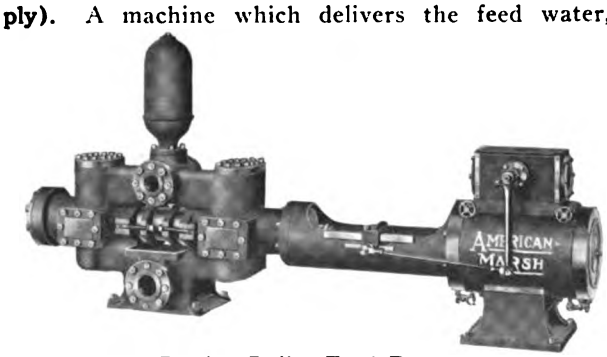
tube type serves as a top head for the boiler and therefore is above the water line. These boilers are commonly of the vertical shell type, the water circulating inside the outer shell of the boiler and around the tubes, steam being generated by the flames and heated gases passing through 48 to 128 2-in. diameter tubes. Some vertical boilers are designed to rest on a circular cast iron base which also serves as the bottom of the ash pan of the fire box, while others have a shell extension below the fire box which rests on a prepared base usually of brick or concrete, the shell extension serving as the ash receiver as well as the boiler base. Another type is designed to be set on a square iron box or ash tray. This arrangement allows placing the boiler on a wood floor without danger of fire as does also the circular iron base.

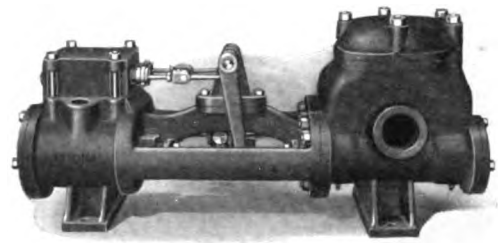
The locomotive type boiler consists of a rectangular steel shell averaging about 3 ft. wide, 4 ft. long and 4 ft. high, having a flat bottom and a circular top surface containing a water compartment, fire box and ash pan. At the rear end of the water compartment is riveted a horizontal cylindrical steel shell enclosing tubes which convey the products of combustion to the smoke stack from the fire box. On top of the water compartment is the steam chest or dome. These boilers are sometimes of the water front and open bottom type, while other types have the water front and water bottom which tend to increase the water circulation. This class of boiler is usually portable, being mounted on heavy wood sills which permit ready movement to any desired position while the boiler is held upright.

The horizontal tubular boiler consists of a steel shell filled with as many tubes from 2 to 4 in. in diameter as is consistent with the circulation and steam space. This type of boiler is unlike the locomotive type in that the water is converted into steam from heat and flame from the combustible matter placed directly under the boiler shell in the bricked fire box or furnace and further heated by the gases passing through the tubes which extend practically the full length of the boiler. In some designs, known as the marine type, the furnace or fire box is located in the lower half of the boiler, the upper half containing the water and steam compartment through which the tubes pass. This type of boiler is designed with a water jacket between the fire box and the outer shell as well as at the rear end through which the flues of the boiler carry the heat to the upper tubes, thus allowing free and complete water circulation.

BOILER FEED PUMP (Locomotive Water Supply). A machine which delivers the feed water, usually heated, to the steam boiler. This apparatus is usually a single or double acting, horizontal, steam-driven pump, commonly used to lift the water into the boiler. It consists of a single or double cylinder steam chest bolted on one end of a horizontal iron or steel frame, while a water chamber is fastened on the opposite end. The device is supported on legs or castings having a flared base, usually cast integral with the steam chest and water chamber, by which it is bolted to the floor. The size and power of the boiler feed pump is based on the capacity and the pressure of the boiler.



Duplex Boiler Feed Pump
The National Steam Pump Co.



American-Marsh Boiler Feed Pump
The American Steam Pump Co.

BOILER, FEED WATER (Locomotive Water Supply). The water supply to a boiler to replace that which is evaporated into steam or blown off. As a matter of economy this water is preferably preheated by exhaust or waste steam.

C

CALKING TOOL. A hand chisel used to drift materials into the joints of a pipe or the seams of a tank or other structure with a view of making them impervious to inside as well as outside pressure, especially of water. A calking tool commonly consists of a flat rectangular steel blade about 1 in. wide and ⅛ in. thick, terminating in an octagonal hand-hold about ¼ in. in diameter. The chisel end is cut square while the shank is offset to form the hand-hold, thus permitting the tool to be gripped when the blade is flat against the work.

Calking Tool

CASING, WELL. An external protective covering, usually tubular, such as lengths of iron piping joined together and employed especially to line the walls of drilled wells. Usually wrought iron pipe of the screw coupler type is used to line deep bored wells, the pipe being driven down into the well as the drilling progresses.

CHIME. The rim around the base of the tub of a wooden water tank, formed by the ends of the staves projecting below the bottom of the floor. The function of the chime is to complete the joint between the crozed staves and the floor boards, and not to bear any weight.

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COAGULATION. The process of forming a gelatinous precipitate in water for the purpose of removing finely divided suspended matter which is not readily removed by sedimentation alone. The common coagulants of alkaline ingredients in water are alum, aluminum sulphate and sulphate of iron. All of these chemicals tend to form gelatine-like substance in the water which is heavy enough to sink slowly to the bottom of the tank, carrying down with it all the fine floating particles of dirt and leaving the water above it thoroughly clarified. See Filter.

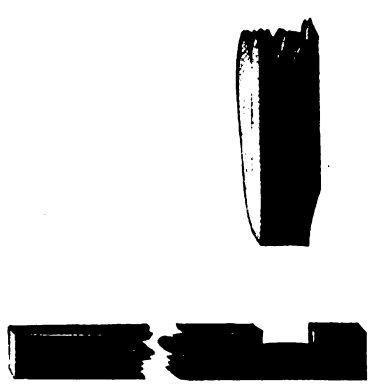
COLLOIDAL MATTER. Matter in a state of semi-solution which must be congealed before it will form a sediment or become thick enough to be filtered out of the water. Silica, for example, is sometimes present in such finely divided particles that, while it may appear to be in solution it is really a mass of fine suspended particles which is the colloidal form.

CRANK SHAFT, WELL HEAD. A shaft with one or more cranks carrying gear wheels designed to be meshed with smaller gears on the countershaft, placed on top of the well-head frame, to operate the connecting rods of a deep well pump. When the shaft has two or more cranks they are placed 180 to 120 deg. apart, thus giving the pump a reciprocating movement. See Pump, Deep Well, Power Head.

CROSSHEAD, DEEP WELL PUMP. The connection or coupling between the piston or plunger rods and the connecting rods of a reciprocating engine, specifically the bar at the end of the piston rod which slides in a chamber fixed to the side of the frame or bed of the engine and connects the piston rod with the connecting rod.

CROSSYOKE, WELL HEAD, DEEP WELL PUMP. A horizontal beam used on a double or triple acting power head to the ends of which are fastened the lower ends of the upright connecting rods of a well-head, while the upper end of the piston or plunger rod of the pump is carried at the center.

This device is designed to actuate the tubular type of piston rods, inside which the solid rod of a lower piston moves independently, as in case of high pressure pumps serving deep wells.



Wood Croze and Chime

CROZE. The cross groove cut into the staves of a wooden tank in which the edge of the floor boards are inserted. This dap is machined into the staves during manufacture at which time the stave is suspended in a traveling frame which moves in a curve of the circumference of the tank and the croze is thereby cut to the shape of the tank bottom. When the stave is driven home on the floor board the croze should fit in a tightly filled joint.

CUTTER, PIPE. A steel tool for cutting or truing the ends of iron pipes. A hook passes under the pipe to hold it while a disc or chisel is forced down upon the pipe by a screw and the implement is rotated by means of a cross bar until the pipe is completely severed.

A Common Form of Pipe Cutter

Another type of cutter consists of a flat U-shaped steel jaw on one end of which is fastened a short, straight steel handle which extends horizontally away from the jaw, while on the opposite end a threaded pressure screw bolt and handle are placed, the lower end of the jaw being equipped with a cutting disc while the end of the pressure screw bolt presses an opposite disc into the pipe. The instrument is designed to be rotated around the pipe by means of the opposite handles.

A shop type of cutter consists of a flat circular casting on the sides of which are fastened four equally spaced cutting knives. The knives are operated by means of feed screws which feed them into the pipe automatically as the cutter is revolved by hand. Opposite D-shaped hand-holes or a ratchet handle provide means of rotating the device.

Ball Valve
Pump Cylinder
Fairbanks, Morse & Co.

CYLINDER, PUMP. A hollow chamber of uniform circular section designed to be placed either in a vertical or horizontal position and used as a working barrel for a piston or plunger fastened to a connecting rod or working rod of a pump. Single cylinders are commonly used in wells of the deep bored type, since they work in an iron casing from 4 to 8 in. in diameter. Two or more cylinders cast integrally are usually used in wells of the open type, the number depending largely on the amount of water to be delivered.

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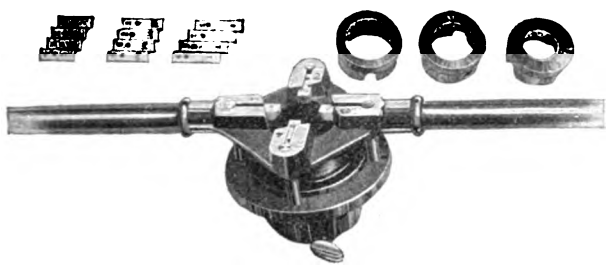
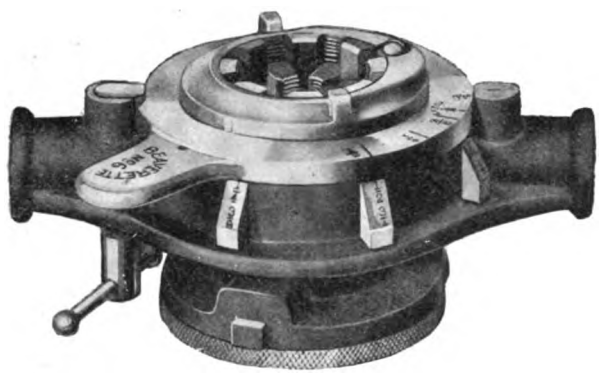
D

DAM. An artificial obstruction such as a bank or mound of earth, a frame of wood, or a wall of masonry, or of steel thrown across a waterway or stream to impound a body of water as a permanent source of water supply and usually located in close proximity to or preferably on the railway right of way. In well developed open country where the rainfall is normal, timber or earth dams, or cribbing reinforced with loose rock are the various kinds used for locomotive water supply. In mountainous country, permanent structures such as masonry dams are frequently necessary, owing to the numerous water sheds which cause a large volume of water to accumulate and develop immense pressure on the dam in a short period of time.

DIE, PIPE. A hollow, internally threaded tool, for cutting screw threads on pipe, etc. It may be made in one piece or in several parts. A die may be a hollow tube, the inner surface of which is partly



Stock and Dies for Small Pipe



Large Pipe Die Stock

grooved to form wedge-shaped cutting teeth; or it may consist of a number of short flat steel strips, the ends forming wedge-shaped teeth, each cutting tool being fastened in a groove on the side of the operating frame. For the use of this tool a special die stock is provided which consists essentially of a circular steel frame in which the die plates or cutting knives are fastened, the frame being equipped with two opposite tubular steel handles by which the device is rotated to cut threads on the pipe. Dies are designed in various sizes to thread pipes up to 12 in. in diameter.

E

EVAPORATION. The process by which water is changed into gas, as by heating it in a locomotive boiler to produce steam. Evaporation also takes place constantly from the surface of all open bodies of water, as lakes and reservoirs. As the percentage of evaporation is greater from broad, shallow bodies of water than from relatively deep restricted areas, the latter form of reservoir is preferable as a source of supply.

EXHAUST HEAD. A funnel-like apparatus placed on the top end of a steam exhaust pipe to prevent oil and condensed steam from being blown off.

This device, averaging about 2 ft. high and 18 in. in diameter, is usually a conical or cylindrical, galvanized steel shell containing steel baffle plates or tubes, inside which the wet steam and cylinder oil from the exhaust pipe is caught to prevent damage to roofs and walls of buildings, etc. At the lower

Exhaust Head for Steam Pipe

end is a small drain pipe through which water formed from condensed steam is returned to the boiler after the cylinder oil has been removed. This apparatus not only saves the roofs and walls of buildings from deterioration but it also furnishes to the boiler, water of condensation which is practically free from lime and impurities.

F

FEED WATER HEATER (Locomotive Water Supply). A contrivance for raising the temperature of boiler feed water, either by steam-heated coils or by direct contact with a jet or spray of steam as in locomotive water stations, where the boiler must frequently supply steam on short notice. This apparatus commonly consists of a cylindrical or cubical cast-iron or steel shell, containing a nest of brass or boiler tubes. The feed water heater is designed to pre-heat water before it enters the boiler by either passing the exhaust steam from the boiler through the heater to circulate around the tubes and heat the feed water passing through them; or to pass the steam through the tubes to heat the water as it circulates around them. In either case, when the feed water is heated to the desired temperature, it passes through a settling chamber and filter in

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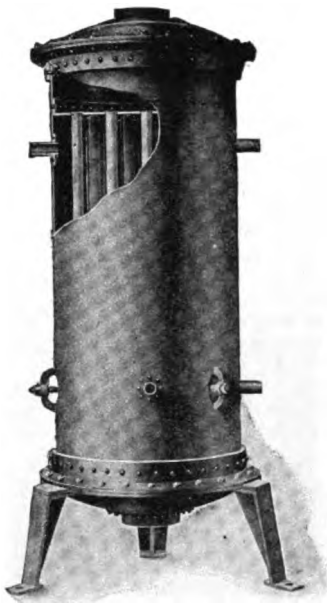

Common Form of Feed Water Heater

which most of the impurities injurious to boilers such as earthy salts and lime are removed, the purified water then passing into the boiler. In some designs a number of corrugated shelves or pans are placed one above the other to collect the lime and salts precipitated from the water. The heater may be either vertical or horizontal and may be set on a masonry base or in a frame of wood or masonry, or laid in cradles, according to its size and weight; or it may be suspended on iron rods from the roof supports of the boiler house. The preheating of feed water is distinctly a fuel economizer as well as a means of freeing hard water from the objectionable salts and dissolved gases.

FILTER. A porous medium through which flowing water is passed to free it from substances mixed mechanically with it, such as a bed of sand, a layer of gravel, anthracite culm, charcoal, coke, asbestos, felt, excelsior, paper, etc., or a combination of two or more such substances or of alternate layers of the same.

Deposits of gravel, sand, etc., through which water flows naturally, afford more or less filtering action. Artificial filters are widely used to purify water. In treating plants at locomotive water supply stations, they are frequently used as supplementary to chemical treatment, to hasten the complete clarification of the treated water. In general, the more obstruction presented to the flow of water through the porous medium, the more efficient is the filter. The filtering material must be cleansed periodically of the impurities collected from the water to prevent it from clogging. This is done by stirring the particles in some way to loosen and eliminate the sludge. Common methods are to reverse the current of water, to apply water and air or steam under pressure, to use stirring machines, or to renew the filtering bed. A common and efficient style of filter consists essentially of a bed of quartz or silica sand with a down flow of water. See Pages 699, 719 and 789.)

FILTRATION. A mechanical process of separating and removing the undissolved particles floating in water, as by passing the liquid through a selected porous medium.

Filtration is commonly employed as a clarifying process supplementary to chemical water softening, usually to expedite the clearing of the liquid after treatment instead of waiting for the suspended mat ter to settle. See Filter.

FOAMING (Boiler). The excessive bubbling of water in a boiler which tends to fill the steam space and dome with bubbles and causes water to be carried into the engine cylinders. The steam thereby loses expansive power and impairs the efficiency of the locomotive. The effect is also to carry over sediment that injures the working parts.

Foaming commonly takes place in boilers containing concentrations of alkaline salts, occurring in the natural water or resulting from treatment with soda ash, the condition being aggravated by the presence of suspended matter. Films of suspended matter form about the steam bubbles which, rising to the surface and being strengthened by collections of alkaline salts, have enough tenacity to produce foam to carry water with the steam. The concentration of alkaline salts which will produce foaming is from 50 gr. to 200 gr. per gal. of water, according to the character of the salts and the percentage of suspended matter present.

The remedies for foaming are (1) frequent periodical blowing off of the boiler to reduce the concentration of the alkaline solution and systematic complete washouts at terminals to remove the suspended matter and sludge, and (2) the cautious use, when the first remedy will not suffice, of anti-foaming compounds as prescribed by a chemist experienced in water treatment.

As foaming is sometimes due to improper handling of the locomotive boiler, it is advisable to obtain an expert inspection, before taking measures for chemical correction of the conditions.

H

HARDNESS (Water). A property of water due to incrusting solids held in solution, usually carbonates of calcium and magnesium and sulphate of calcium.

Permanent hardness is due to sulphates and chlorides of calcium and magnesium, forming hard scale, while temporary hardness is due to calcium and magnesium bi-carbonates. The sum of the temporary and permanent hardness is known as the total hardness of water. The quantities of these substances in water are chemically measured in degrees of hardness, one degree being equal to one part per 100,000 parts of water. More common usage in practical water service is to express the dissolved solids in terms of grains per U. S. gallon or the solids eliminated in pounds per 1000 gallons. Other minerals are similarly considered according to the ratios of their molecular weights with that of calcium.

HEAD (of Water). The actual vertical distance (at any point in a pipe) of water below the free surface. See Water Column. Also Water Supply, Locomotive.

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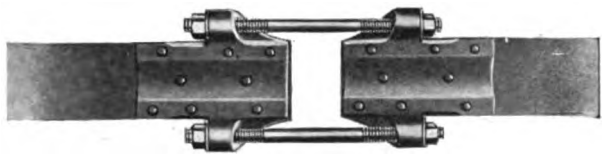
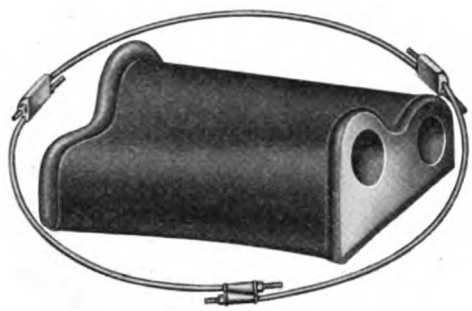
HOOP. One of a number of outside metal strips horizontally encircling the tub of a wooden water tank to keep the staves close together and thus prevent water from leaking out between them. Hoops are preferably of wrought iron and although formerly made in complete circular form with ends lap jointed and riveted, with a view to being driven from the top to a tight fit around a tapering tub, they are now preferably made in two or more sections which are provided with bolts and lugs for tightening about the staves of tubs made without a taper. A hoop may be a band of sheet iron, or a



Lugs for a Flat Tank Hoop



Lug for a Round Tank Hoop

Lug for Half Round Tank Hoop

round, oval or half oval rod. The following specifications for hoops were adopted by the A. R. E. A. in 1920:

1. **Material.** (a) Hoops are to be made of the best refined double rolled wrought-iron, tough, fibrous and uniform in character; free from blisters, cinder spots, flaws or imperfect edges, and must be thoroughly welded during rolling.

(b) Test specimens of uniform sectional area of at least ½ a sq. in. for a length of 10 in. shall show an ultimate strength of 52,000 lb. per sq. in., an elastic limit of not less than 26,000 lb. per sq. in. and an elongation of 20 per cent in a distance of 8 in.

(c) Full-size test pieces shall stand bending cold by blows of a hammer through 180 deg., and close down upon themselves without sign of fracture. All material will be subjected to inspection, and the contractor shall furnish all test specimens and facilities for making tests at his sole cost and expense.

2. **Shape.** Hoops shall be round in cross-section, the same size throughout and bent to a true radius to fit the tank.

3. **Size.** Hoops shall be of such size and so spaced that the stress shall not exceed 12,500 lb. per sq. in. when computed from the area at the base of the thread. No hoop less than ¼ in. in diameter shall be used.

4. **Spacing.** Spacing of hoops to be figured by the following formula:

$$\text{Hoop spac. (in.)} = \frac{\text{Safe load on hoop (lb.)}}{2.6 \times \text{dia. (ft.)} \times \text{depth* (ft.)}}$$

*Note.—Depth refers to distance from top of stave to point where hoop is to be located.

The top hoop shall be placed within 2 in. of the top of the staves. No space between hoops shall exceed 21 in. Hoops shall be so placed that lugs will not come in a vertical line.

On account of the swelling of the tank bottom the hoops near the bottom may be subjected to a strain greater than that due to the water pressure alone; therefore additional hoops should be provided. Two hoops of the size used next above should be placed around the bottom opposite the croze, one of which shall not be considered as withstanding any water pressure.

5. **Threads.** The ends of each section of hoop shall be threaded with U. S. standard threads for a length of 4½ in.

6. **Nuts.** Each end of each section shall be provided with 2 hexagon nuts tapped to fit the thread on the hoops.

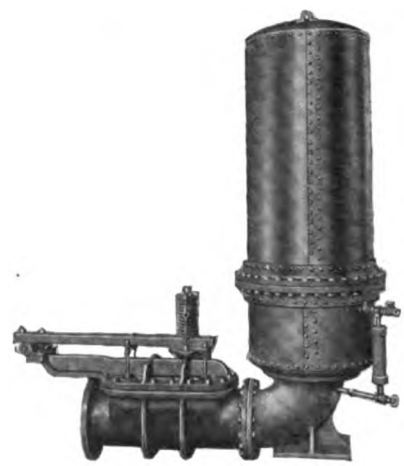
7. **Lugs.** The lugs shall be of standard pattern, at least 8 in. long and as strong as the hoop; they shall preferably be made of malleable iron, but cast iron may be used if approved by the engineer.

8. **General.** Each hoop shall be made in 3 sections for 16 ft. by 24 ft. tanks and in 4 sections for 20 ft. by 30 ft. tanks.

The several pieces constituting one hoop shall be tied together for shipment.

All pieces shall be furnished in full lengths, unwelded, and must not vary more than ½ in. from the lengths given on the order.

HYDRAULIC RAM (Locomotive Water Supply). An automatic machine by which the energy of a gravity flow of water is utilized to compress air to force a portion of the water to a height greater



Rife Hydraulic Ram
The Rife Hydraulic Engine Manufacturing Co.

than the source of supply. This self-contained pumping unit commonly consists of an upright air chamber (under which is a check valve) supported on an arrangement of flanged piping which constitutes the body of the ram and to which is attached an overflow valve. In operation the feed water is piped down into the body of the ram from the source of supply and passes out through the overflow valve until the force of the incoming column

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Deming Hydraulic Ram
The Deming Co.

becomes sufficient to raise the valve to its seat, a small portion being forced at the same time through the check valve into the air chamber, slightly compressing the air within, closing the check valve and preventing the water from returning to the feed pipe. This compressed air gradually attains sufficient force to lift the small quantity of water from the air chamber through the discharge pipe into the storage tank. When the check valve closes, the column of water in the feed pipe rebounds slightly, removing the pressure from the overflow valve and allowing it to open by gravity, thus completing one cycle of operation which is automatically and continuously repeated. The hydraulic ram is a frequent solution of the problem of obtaining an economical and automatic supply of running water.

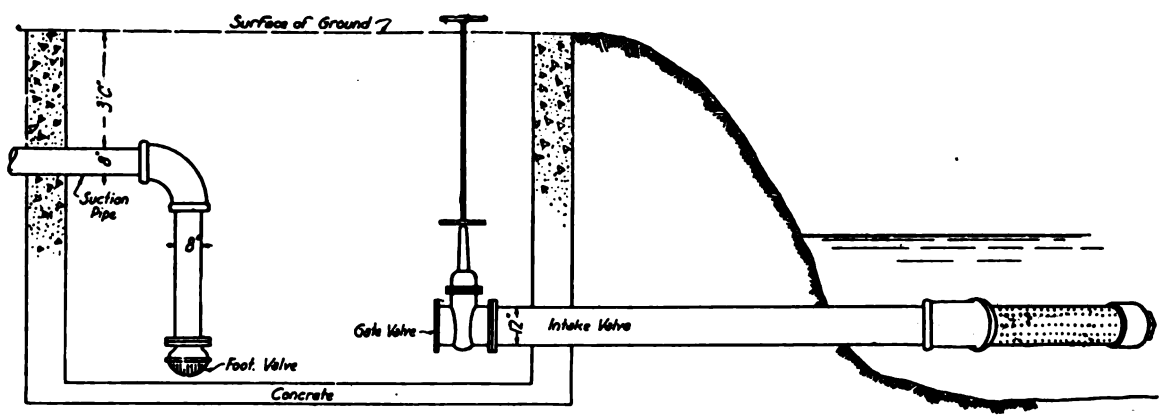
I

INDICATOR, WATER TANK. A device used to show the depth of water in a tank, consisting commonly of a strip of wood bearing foot marks and numbers painted in black on a white background and fastened vertically to the outside of a water tank as a marker on which a metal pointer suspended from a line attached to a float on the water in the tank, slides up or down as the tank is filled or emptied. Another type is the ball indicator, in which a metal ball rises above the apex of the tank roof as the water rises within the tank, the ball being fastened on the top of a vertical rod which rises through the roof from the float within the tank to which its lower end is secured.

INJECTOR (Locomotive Water Supply). A boiler feed device, in which the momentum of a steam jet carries a stream of water into the boiler. This apparatus consists of integrally arranged metal cylinders in which steam condenses and heats the water which it forces along into the boiler. The action of an injector is due to the fact that the velocity of a jet of steam emited from the cylinders is greater than the velocity of water flowing under the same conditions.

Injectors are of two types, automatic and positive, the positive type being also known as the double tube injector. They differ in that the overflow of the automatic type opens and closes through the action of the injector itself and usually has but a single set of jets, while the positive type overflow is closed mechanically and has two sets of jets, one for lifting the water and the other for forcing it to the boiler. The automatic injector is generally used for portable and stationary boilers. An advantage of this device is, that in case the locomotive water supply is suddenly cut off, causing the suction hose or supply pipe to run dry, the injection will again function automatically on the repletion of the supply.

INTAKE. That portion of a pipe or other apparatus through which water enters from the source of supply, such as the end of an intake pipe. When possible, the pipe is located in quiet water, sometimes formed by a rock jetty or by the driving of piling near the pipe, as a protection against debris during high water. A cylindrical or cup-shaped strainer or other device is placed over the end to prevent the passage of foreign matter into the pipe.



Sketch of a Typical Intake

INTAKE LINE. A line of pipe conveying water by gravity from the source of supply to an intake well or sump. Commonly an intake line, usually cast iron, is of the same diameter as the intake pipe to which it is attached and somewhat larger than the suction pipe to which it delivers water. The intake line is located well below the surface of the supply and far enough above the bottom to be clear of debris, etc. On the well or sump end of the intake line is placed a water-gate valve by which the flow of water from the source of supply is shut off when repairs are to be made or debris removed from the intake well.

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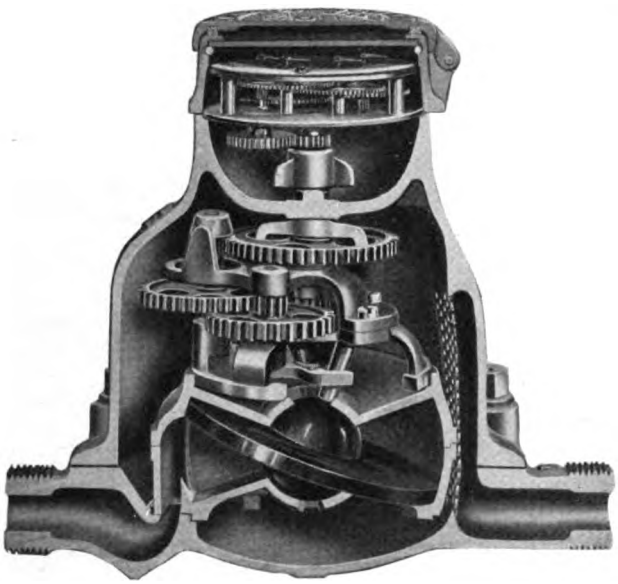
M

METER, WATER. An instrument for measuring and automatically recording the flow of water through it. Water meters usually act by a gyrating disc, by a rotating vane or by piston displacement.

The objects of thus measuring water used for locomotive supplies are to check locomotive performance, to compare costs of fuel and pumping, and in case of water furnished to others, to arrive at a fair basis for payment. A water meter should be periodically tested and if necessary removed for overhauling. Some types can be removed and exchanged without interfering with the delivery of water while others require a by-pass pipe through which the water is turned while repairs are in progress.

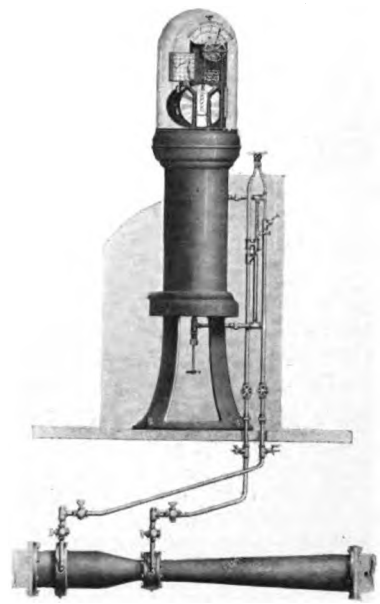
A widely used type is the flat disc meter, a squat, flask-shaped device of non-corrosive metal designed



Flat Disc Meter
The Worthington Pump and Machinery Co.

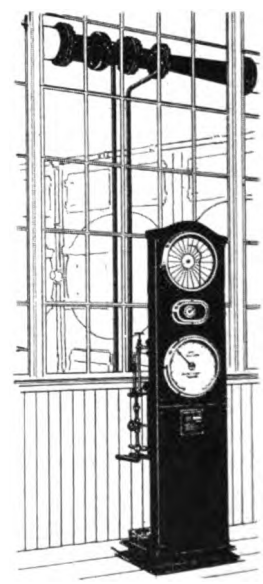
to be attached to a pipe line by means of opposite inlet and outlet pipe connections in the base casting, on which the top case is fastened by flange screws with a gasket between the flanges, while the register box surmounting the top case is similarly secured. Within the bottom portion of this container is an interior case supporting near the bottom a radially-cut hard rubber disc with a central globe bearing and a metal spindle moving in a water-balanced chamber to measure the flow of the water, which, in passing from the inlet through a strainer and the disc chamber to the outlet, causes the disc to oscillate slowly, the spindle bearing against a train pawl and actuating the intermediate train above, which in turn engages gears so mounted as to operate the registering device beneath the dial over which pointers revolve to indicate the flow of water through the meter in cubic feet, gallons or metric units.

The turbine type is used principally to measure the flow through water pipes of more than three inches diameter. This is a velocity type, designed to handle large volumes of water with minimum loss of pressure. The water enters an inlet chamber and passes through a strainer to the main chamber which contains a double horizontal wheel carrying



Simplex Meter Register Operated by Venturi Tube
The Simplex Valve & Meter Co.

two sets of vanes arranged to secure a water balance and surrounded by a volute pattern chamber designed to provide at all points of the circumference the proportional cross-sectional area required for the volume of water discharged by the wheel, thus minimizing the frictional losses due to sudden alterations in flow. The gear train and registering device are above and actuated by the vertical center spindle on which the turbine wheel turns. The interior frame of the meter is removable to permit of repairs to parts without breaking the pipe line. The wheel is of hard rubber while the metal parts are non-corrosive or covered with corrosion preventing paint.



Venturi Meter
Builders Iron Foundry Co.

A meter depending on the pressure effects of a tube drawn to a narrow throat at a middle flange has a hollow float resting in a U-tube of mercury, the variation in the levels of which are employed to indicate the flow of water through the tube placed in the pipe line. This meter is made in a wide range of sizes suitable for pipe lines up to 60 in. diameter. It may be equipped with either a dial or a cylindrical recording device.

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P

PENSTOCK. See Water Column. Also Water Supply, Locomotive.

PERCOLATION. The passage of water through a mass of porous earth or rock or through a prepared bed of charcoal of sand or other material with a view to separating and removing impurities from it. See Filter.

PIPE (Locomotive Water Supply). Pipe used to convey water for locomotives from the source of supply to the delivery device.

Water pipe for locomotive supply includes suction and delivery lines when, as is usual, the water is to be forced to the point of delivery. Cast iron water pipe is commonly 12 ft. or 16 ft. long, wrought iron pipe is made in random lengths averaging 20 ft. and wooden pipe is made in random lengths of 3 ft. to 20 ft. Cast iron water pipe, made 3 in. in diameter and over with bell and spigot joints is largely used in locomotive water supply lines, while sheet iron, wrought iron and wood are materials also in demand though not so generally used for this purpose. The fittings of water pipe include curves, offsets, elbows, bends, tees, crosses, reducers, sleeves, caps and plugs.

Cast iron pipe is foundry made from pig iron, being usually cast vertically between the sanded surfaces of a core and an outer mold, all held in a sectional, knockdown iron flask, the joints and fittings being similarly but specially moulded. The thicknesses of the walls of cast iron pipe depend on the tensile strength of the metal, which varies with the process of manufacture. The American Water Works Association recognizes eight grades of cast iron pipe, in classes A to H, inclusive, the thicknesses of which are based on safe working pressure for metals of tensile strengths of 15,000 lb. to 40,000 lb. per sq. in., according to the service expected. Therefore, the suitability of water pipe for a given service is based on the pressure which it will withstand, rather than on the thickness of the walls alone. The usual tensile strength required in America is 18,000 lb. per sq. in. of section. In Europe, where the metal is more expensive than in America, water pipe is made thinner and of metal having greater tensile strength for a given service.

Advantages of the bell and spigot joint are that it allows the resilience necessary in pipe lines in yielding ground, while it is not too rigid to permit expansion and contraction, is inexpensive to manufacture and can be laid by comparatively unskilled labor, especially when the joint is prepared in the factory where oakum and lead held in place in the bell by means of a circle of wedges, the whole being protected by a removable concrete plug. Under ordinary conditions this type of joint affords flexibility, tightness under pressure and durability, enhanced by the elimination of all iron to iron contact. Turned and bored bell and spigot joints are specialties considered necessary in some cases abroad, but rarely used in America.

Flanged joints are invaluable for many special purposes, flanged pipe being joined by means of bolts through contiguous flanges between which gaskets are placed. While high pressure lines in Europe are laid exclusively of this type of joint, its general use in America is limited to power units and the like, where the foundations have little chance of settling. It is also used in self-supporting, vertical lines which supply elevated water tanks, in suction lines and at the ends of lines in pump houses, etc. An advantage of the flanged joint is the readiness with which a length of pipe may be unbolted, rolled out of the line and replaced without disturbing the other lengths. Flexible joints are specialties of value where yielding bends are necessary. Threaded end cast iron pipe with threaded couplings is usually reserved for corrosive or acid water, while plain end pipe with bolted sleeve couplings is frequently used on water lines in special cases as for replacements of single lengths of pipe. These styles have the advantage of availability of the total length of the tube for service. Sheet metal pipes of various types are frequently laid where special service is required as in pumping stations. Most of these are flanged pipe, either riveted or spirally wound and reinforced. All black iron pipe is preferably coated with tar asphalt or some other preservative.

Wrought iron pipe, preferably galvanized, is frequently laid in water lines. It is commonly of 3 in. inside diameter and under and is laid in temporary or small branch lines. The random lengths vary from about 18 ft. to 22 ft., the pipes being threaded outside and joined with threaded couplings. Advantages are its comparative light weight, low cost and the readiness with which it can be installed. Wood pipes made of bored timber or built up of wooden staves, and variously strengthened by windings of wire, flat metal bands, etc., are used for locomotive water supply lines where the pressure is not great, usually in gravity lines. This pipe is light and can be quickly and cheaply laid.

PIPE, CAST IRON. A pipe made of pig iron, cast between the outer surface of a round central core and the inner surface of an outer cylindrical mold. The mold and core are held in a sectional collapsible iron flask which stands on end in a pit where the ore is poured between the sanded surfaces of the core and mold, where it remains until cooled, when the flask is knocked down and the pipe is removed as in other foundry practice. Cast iron water pipe is usually made with bell and spigot joints, but flanged joints are also used especially for connections at the engine house. The bell and spigot joint is favored for long pipe lines on account of its simplicity and flexibility and the readiness with which it can be laid by comparatively unskilled labor. Factory made bell and spigot joints are furnished ready leaded and are recommended to save labor in the field. Cast iron pipe is commonly made in diameters of 3 in. and over, in 12 ft. lengths and also in 16 ft. lengths, an advantage of the longer pipe being a diminution in the number of joints needed.

The thickness of the pipe depending on the character of the material used, is greater in American made pipe than in that manufactured in Europe, where iron ore is more expensive. The present American tendency is toward thinner walled pipe of high grade. See pipe, (Locomotive Water Supply).

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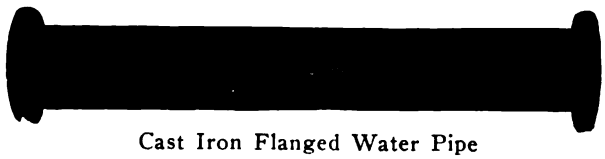
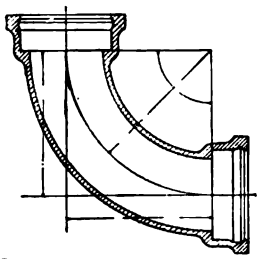
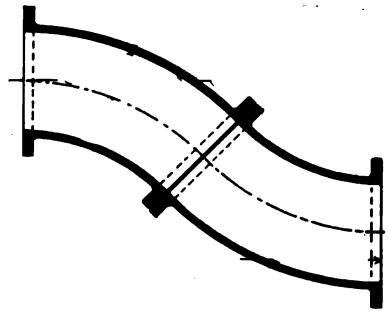


Cast Iron Flanged Water Pipe

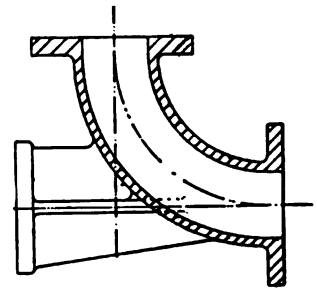
Cast Iron Bell and Spigot Water Pipe



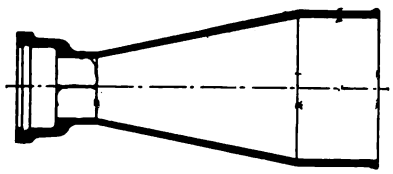
One-Fourth Curve with Bell Ends



Flanged Offsets

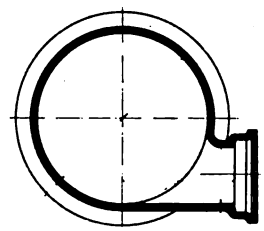


90-Deg. Flanged Elbow with Base

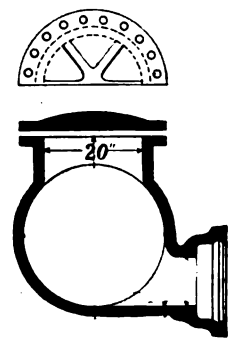


Small End Bell Reducer

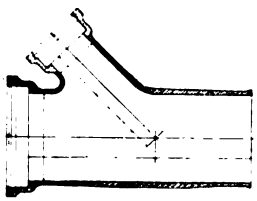
Cross with Flange and Spigot Run and Bell and Flange Branches



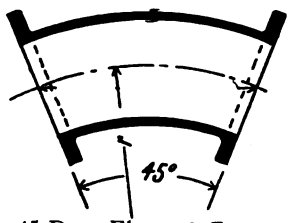
Standard Blow-Off Branch



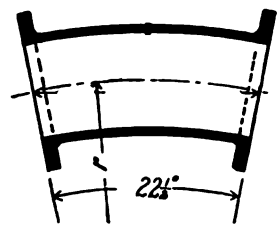
Standard Blow-Off Branch with Manhole



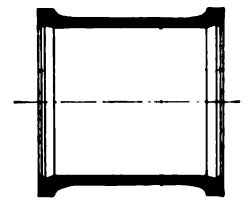
Bell End Y Branch



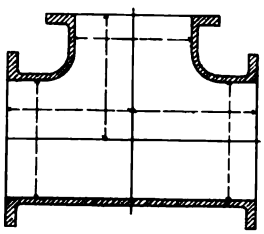
45-Deg. Flanged Curve



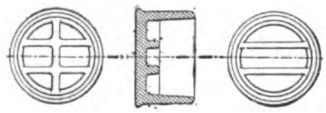
22½-Deg. Flanged Curve



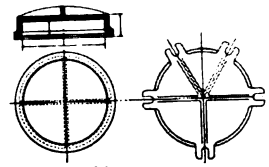
Pipe Joint Sleeve



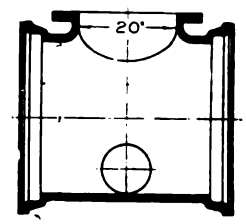
Flanged Tee



Pipe Plug



Pipe Cap



Blow-Off Branch with Manhole

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Standard Specifications of the American Water Works Association for Cast Iron Pipe and Special Castings

Section 1. **Description of Pipe.** The pipe shall be made with hub and spigot joints, and shall conform accurately to the dimensions given in Tables Nos. 1 and 2. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 ft. in length, exclusive of socket.

Pipe with thickness and weight intermediate between the classes in Table No. 2 shall be made of the same outside diameter as the next heavier class; pipe with thickness and weight less than shown by Table No. 2 shall be made of the same outside diameter as the Class A pipe; and pipe with thickness and weight more than shown by Table No. 2 shall be made of the same outside diameter as the Class D Pipe.

All pipe having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipe of each standard outside diameter shall be gradually increased for a distance of about 6 in. from each end of the pipe so as to obtain the required standard thickness and weight for each size and class of pipe.

Description of Pipe

For pipe of each size from 4-in. to 24-in. inclusive, there shall be two standards of outside diameter, and for pipe from 30-in. to 60-in. inclusive, there shall be four standards of outside diameter, as shown by Table No. 1.

For pipe 4-in. to 12-in. inclusive, one class of special castings shall be furnished, made from Class D pattern. Those having spigot ends shall have outside diameters of spigot ends midway between the two standards of outside diameter, as shown by Table No. 1, and shall be tapered back for a distance of 6 in.

For pipe from 14-in. to 24 in. inclusive, two classes of special castings shall be furnished; Class B special castings with Classes A and B pipe, and Class D special castings with Classes C and D pipe; the former shall have cast on them the letters "AB" and the latter "CD." For pipe 30-in. to 60-in. inclusive, four classes of special castings shall be furnished, one for each class of pipe, and shall have cast on them the letter of the class to which they belong.

Section 2. **Allowable Variation in Diameter of Pipe and Sockets.** Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gauges, and no pipe will be received which is defective in joint room from any cause. The diameters of the sockets and the outside diameters of the spigot ends of the pipe shall not vary from the standard dimensions by more than 0.06 for pipe 16 in. or less in diameter; 0.08 in. for 18 in., 20 in. and 24-in. pipe; 0.10 in. for 30-in., 36-in. and 42-in. pipe; 0.12 in. for 28-in.; and 0.15 in. for 54-in. and 60-in. pipe.

Section 3. **Allowable Variation in Thickness.** For pipe whose standard thickness is less than 1-in., the thickness of metal in the body of the pipe shall not be more than 0.08 in. less than the standard thickness, and for pipe whose standard thickness is 1 in. or more, the variation shall not exceed 0.10 in. except that, for spaces not exceeding 8 in. in length in any direction, variations from the standard thickness of 0.02 in. in excess of the allowance above given shall be permitted. For special castings of standard patterns a variation of 50 per cent. greater than allowed for straight pipe shall be permitted.

Section 4. **Defective Spigots May Be Cut.** Defective spigot ends on pipe 12 in. or more in diameter may be cut off in a lathe and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent. of the total number of accepted pipe of each size shall be cut and banded, and no pipe shall be banded which is less than 11 ft. in length exclusive of the socket.

In case the length of a pipe differs from 12 ft. the standard weight of the pipe given in Table No. 2 shall be modified in accordance therewith.

Section 5. **Special Castings.** All special castings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The diameter of the sockets and the external diameters of the spigot ends of the special castings shall not vary from the standard dimensions by more than 0.12 in. for castings 16 in. or less in diameter; 0.15 in. for 18-in., 20-in. and 24-in.; 0.20 in. for 30-in., 36-in. and 42-in.; and 0.24 in. for 48-in., 54-in. and 60-in. These variations apply only to special castings made from standard patterns.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The manufacturer shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans, and made of the best quality of mild steel, with hexagonal heads and nuts and sound, well-fitting threads.

Section 6. **Marking.** Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4-in. may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1920	1920	1920
1	2	3

etc.; also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall not be less than 2 in. in length and 18 in. in relief for pipe 8 in. in diameter and larger. For smaller sizes of pipe, the letters may be 1 in. in length. The weight and the class letter shall be conspicuously painted in white on the inside of each pipe and special casting after the coating has become hard.

Section 7. **Allowable Percentage of Variation in Weight.** No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipe more than 16 in. in diameter, and no excess above the standard weight by more than 5 per cent for pipe 16 in. or less in diameter, and 4 per cent for pipe more than 16 in. in diameter, and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent.

No special castings shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent for pipe 12 in. or less in diameter, and 8 per cent for larger sizes, except that curves, Y pieces and breeches pipe may be 12 per cent below the standard weight, and no excess above the standard weight of more than the above percentages for the several sizes will be paid for. These variations apply only to castings made from the standard patterns.

Section 8. **Quality of Iron.** All pipe and special castings shall be made of cast iron of good quality and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

Section 9. **Tests of Material.** Specimen bars of the metal used, each being 26 in. long by 2 in. wide and 1 in. thick, shall be made without charge as often as the engineer may direct; and in default of definite instructions, the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 in. apart, and loaded in the center, shall support a load of 2,000 lb. and show a deflection of not less than 0.30 in. before breaking; or, if preferred, tensile bars shall be made which will show a breaking point of not less than 20,000 lb. per sq. in. The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from

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those above given, a proper allowance therefor shall be made in the results of the tests.

Section 10. **Casting of Pipe.** The straight pipe shall be cast in dry sand molds in a vertical position. Pipe 16 in. or less in diameter shall be cast with the hub end up or down, as specified in the proposals. Pipe 18 in. or more in diameter shall be cast with the hub end down.

The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Section 11. **Quality of Castings.** The pipe and special castings shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

Section 12. **Cleaning and Inspection.** All pipe and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust and approved in these respects by the engineer immediately before being dipped.

Section 13. **Coating.** Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 deg. Fahrenheit immediately before it is dipped and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipe are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 deg. Fahrenheit (or less, if the engineer shall so order) and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated the pipe shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

Section 14. **Hydrostatic Test.** When the coating has become hard, the straight pipe shall be subjected to a proof by hydrostatic pressure, and if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressure to which the different sizes and classes of pipe shall be subjected are as follows:

Classes of Pipe	20 in. Diam. and larger Lb. per Sq. In.	Less than 20-in. Diam. Lb. per Sq. In.
Class A Pipe	150	300
Class B Pipe	200	300
Class C Pipe	250	300
Class D Pipe	300	

Section 15. **Weighing.** The pipe and special castings shall be weighed for payment under the supervision of the engineer after the application of the coal tar pitch varnish. If desired by the engineer, the pipe and special castings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 lb.

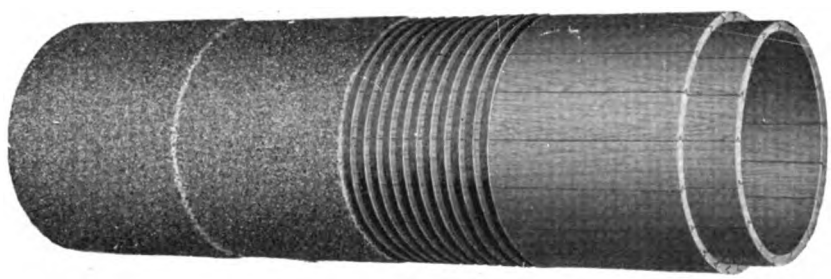
Section 16. **Contractor to Furnish Men and Materials.** The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipe and special castings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

Section 17. **Power of Engineer to Inspect.** The engineer shall be at liberty at all times to inspect the material at the foundry and the molding, casting and coating of the pipe and special castings. The forms, sizes, uniformity and condition of all pipe and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings.

Section 18. **Inspector to Report.** The inspector at the foundry shall report daily to the foundry office all pipe and special castings rejected, with the causes for rejection.

Section 19. **Castings to Be Delivered Sound and Perfect.** All the pipe and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect. And any defective pipe or other castings which may have passed the engineer at the works or elsewhere shall at all times be subject to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the contractor shall not be held liable for pipe or special casting found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipe not to injure the coating, and no pipe or other material of any kind shall be placed in the pipe during transportation or at any time after they receive the coating.

Section 20. **Definition of the Word "Engineer."** Wherever the word "Engineer" is used herein it shall be understood to refer to the engineer or inspector acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them.



Steel Bound Wood Water Pipe
The Michigan Pipe Co.

PIPE, WATER, WOOD (Locomotive Water Supply). A pipe made of a longitudinally bored timber or built up of wood staves.

Wooden water pipe, while not suitable for service involving the highest pressures, possesses many advantages and can be readily reinforced to increase its strength. It is unaffected by electrolysis, sanitary, of light weight, not easily broken and can be laid quickly and economically. It is in a measure a protection against freezing and can be laid readily in a wet trench. Bored wooden pipe is an early type still in use for supplies 4 in. in diameter and under, although larger pipes are obtainable. It is commonly made from squared timber in 8 ft. to 12

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ft. lengths with 6 in. to 12 in. sleeve connections of mortise and tenon joints 3 in. to 4 in. long, 4 in. by 4 in. timber being used for 2 in. pipe and 8 in. by 8 in. to 12 in. by 12 in. timber for 4 in. inside diameter pipe, according to the service required. This type is not commonly used in other than light pressure gravity lines.

Reinforced wood stave pipe in all sizes from 4 in. to 48 in. inside diameter is frequently used in gravity lines under working pressures up to 125 lb. per sq. in. and for direct pumping lines under working pressures up to 40 lb. and emergency pressures up to 90 lb. per sq. in. It is constructed of concentrically cut, tonged and grooved 8 ft. to 12 ft. strips one to two inches thick, dressed to two or three inches wide to suit the diameter of the pipe with mortise and tenon joints. The staves are variously secured against bulging, usually by means of double tongues and grooves as well as outside wrappings of wire or flat metal. One type is spirally wound with tarred flat steel bands, after which it is covered with a thick layer of tar and asphalt into which a coating of sawdust is pressed.

PIPE, WROUGHT IRON (Locomotive Water Supply). Pipe which is seamless or rolled and welded from wrought iron, usually in 20 ft. random lengths with outside threaded ends designed to be joined by means of wrought iron couplings with corresponding inside threads.

Wrought iron lends itself readily to the manufacture of pipes of diameter of 12 in. and under, which are used for well-drill rods, for casings of wells, and for the smaller branch and temporary water supply lines. An advantage of this pipe is its adaptability to quick and economical construction. It is preferably galvanized or furnished with some durable protective coating, special attention being given to preserving the metal at the joints from rust.

American Society for Testing Materials Standard Specifications for Welded Wrought-Iron Pipe

(Adopted in 1918.)

1. These specifications cover "standard" and "extra strong" welded wrought-iron pipe, but not "double extra strong" pipe.

2. (a) All pipe to be used on locomotives and cars shall be of coiling or bending quality.

(b) Unless otherwise specified on the purchase order, inspection and all tests except the hydrostatic pressure test shall be made by the purchaser at destination, and at his expense.

1. Manufacture

3. (a) The iron shall be made from muck bars, made from puddled pig iron, free from any admixture of iron scrap or steel.

(b) All pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 in. in nominal diameter shall be lap-welded.

4. **Iron Scrap.** This term is applied only to foreign or bought scrap and does not include local mill products, free from foreign or bought scrap.

2. Physical Properties and Tests

5. (a) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in	40,000
Yield point, lb. per sq. in	24,000
Elongation in 8 in., per cent	12

Table 1.—Hydrostatic Pressures for Welded Pipe.

(Pressure expressed in pounds per sq. in.)

Inside Diam., In.	"Standard" Pipe Butt-Weld	"Standard" Pipe Lap-Weld	"Extra Strong" Pipe Butt-Weld	"Extra Strong" Pipe Lap-Weld
⅛	700	.....	700	.....
¼	700	.....	700	.....
⅜	700	.....	700	.....
½	700	.....	700	.....
¾	700	.....	700	.....
1	700	.....	700	.....
1¼	700	1000	1500	2500
1½	700	1000	1500	2500
2	700	1000	1500	2500
2½	800	1000	1500	2000
3	800	1000	1500	2000
3½	.....	1000	.....	2000
4	.....	1000	.....	2000
4½	.....	1000	.....	1800
5	.....	1000	.....	1800
6	.....	1000	.....	1800

(b) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed ¾ in. per minute.

6. All pipe shall be tested at the mill to the hydrostatic pressures specified in Table 1.

7. A section of pipe 6 in. in length shall be flattened until broken by repeated light blows of a hammer or by pressure; the fracture developed shall have a fibrous appearance.

8. For pipe 2 in. or under in diameter, a sufficient length of coiling or bending pipe shall bend cold through 90 deg. around a cylindrical mandrel, the diameter of which is 15 times the nominal diameter of the pipe, without developing cracks at any portion and without opening at the weld.

9. (a) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(b) Tension test specimens shall be longitudinal.

(c) All specimens shall be tested cold.

10. One of each of the tests specified in Sections 5, 7 and 8, may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

11. If the results of the physical tests of any lot do not conform to the requirements specified in Sections 5, 7 and 8, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

III. Standard Weights

12. (a) The standard weights for pipe of various inside diameters are given in Table II.

(b) Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

13. The weight of the pipe shall not vary more than 5 per cent from that specified in Table II.

IV. Workmanship and Finish.

14. (a) For pipe 1½ in. or under in inside diameter, the outside diameter at any point shall not vary more than 1/64 in. over nor more than 1/32 in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall not vary more than 1 per cent over or under the standard size.

(b) All "standard" pipe shall be provided with the prevailing standard threads, which make a tight joint when tested to the specified internal hydrostatic pressure at the mill. The threads shall not vary more than one and one-half turns either way, when tested with a Pratt & Whitney standard gage. All burrs at the ends of the pipe shall be removed.

(c) Unless otherwise ordered, pipe shall be furnished in random lengths of 16 to 22 ft., but not more than 5 per cent of the total number of lengths furnished may be "jointers," which are two pieces coupled together. When ordered with plain ends, 5 per cent may be furnished in lengths of 12 ft. or over.

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Table II.—Standard Weights of Welded Pipe.

(All dimensions are nominal.)

Dimensions			"Standard" Pipe Weight of Pipe Linear Foot, Threaded & with Couplings, lb.	"Extra Strong" Pipe Weight of Pipe Linear Foot, Plain Ends lb.
Inside Diam., In.	Number of Threads per Inch.	Outside Diam. In.		
⅛	27	0.405	0.25	0.31
¼	18	0.540	0.43	0.54
⅜	18	0.675	0.57	0.74
½	14	0.840	0.85	1.09
¾	14	1.050	1.13	1.47
1	11½	1.315	1.68	2.17
1¼	11½	1.660	2.28	3.00
1½	11½	1.900	2.73	3.63
2	11½	2.375	3.68	5.02
2½	8	2.875	5.82	7.66
3	8	3.500	7.62	10.25
3½	8	4.000	9.20	12.51
4	8	4.500	10.89	14.98
4½	8	5.000	12.64	17.61
5	8	5.563	14.81	20.78
6	8	6.625	19.19	28.57

(d) Each "standard" pipe shall be provided with a coupling having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings shall be of wrought iron.

(e) Unless otherwise specified "extra strong" pipe shall be furnished in random lengths, with plain ends.

15. The finished pipe shall be reasonably straight and free from injurious defects.

V. Inspection and Rejection.

16. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's work which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications.

(b) When tests and inspection are made at the place of manufacture, they shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. Pipes which develop injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

18. Samples tested in accordance with Section 2 (b), which represent rejected pipe, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for a rehearing within that time.

PINION SHAFT. A steel shaft resting and revolving in journals fastened in front and near the top of a well head frame carrying one or more small gears (designed to be meshed with large gears on the crank shaft) as well as the fly wheel by means of which the machine is belt-connected to the actuating power unit. See Pump, Triplex.

PIPE. Any long tube or hollow body of metal, concrete, earthenware, wood or the like, used to conduct water, steam, gas, etc.

The railway uses of pipe include conveying water under pressure, as for supplies pumped to storage tanks or reservoirs for locomotive use, as well as hot water and steam for heating purposes; and pipe not designed for pressure use, but for the disposal of storm water and sewage through culverts, sewers and drains. See Pipe, (Locomotive Water Supply).

PIPE, DISCHARGE. A line of cast iron, wrought iron, sheet iron, steel or wooden pipe laid for the purpose of carrying water to an objective point, as a tank or reservoir; particularly from the pump to the elevated storage tank or water columns erected to supply water to locomotives. These supply lines are usually laid in trenches below ground, especially where there is necessity for protection against frost. Metal pipe commonly used in discharge pipe lines consists of either cast iron with bell and spigot or flanged joints, or wrought iron with screw couplings. While wrought iron pipe with flanged joints is usually used as a connection between the pumping unit and the main pipe line, cast iron pipe of the bell and spigot type with leaded joints, is commonly used in the main discharge line. Wrought iron pipe with screw couplings is generally used in temporary lines as it can be removed and relayed more readily and economically than pipe with flanged or leaded bell and spigot joints.

PIPE, INTAKE. A short length of pipe placed on the fluid end of a suction pipe, through which water passes from the source of supply to the pump.

The function of an intake pipe in connection with a pumping station is to furnish an uninterrupted supply of water to the pump as well as to prevent debris carried by the water from entering the intake or the suction pipe. The design of an intake pipe depends largely on the source of water supply and the character and quantity of the matter carried by the water.

It is common practice to install a screened intake pipe in an open box so placed as to protect the supply from debris and silt. Intake pipes commonly vary from 3 in. to 12 in. in diameter and from 6 ft. to 50 ft. in length, depending on the amount of water to be pumped. Commonly this pipe is larger than the suction pipe to which it is coupled. It is frequently perforated with a series of small holes, sometimes supplemented with a fine mesh screen, by which the suspended matter is caught before the water passes into the pipe.

PIPE, IRON, BLOW OFF BRANCH. A casting with a small diameter aperture at the base and at right angles with the main line designed to form a connection for a blow off branch.

Large diameter castings of this type have manhole apertures and covers fitted in the top.

PIPE, IRON, CAP. A casting designed to fit over the outside of the end of a pipe to close the aperture. It may be tapped for small pipe connections and secured by means of threads, flange bolts or other fastenings.

PIPE, IRON, CROSS. A branch casting is a connection with bell ends providing for connections on four sides at right angles, opposite bells fitting the main and smaller or branch line pipes, spigot end branch castings being specials.

PIPE, IRON, ELBOW. A short pipe bend, usually a ¼ or 90 deg. curve with equal legs and with suitable terminal pipe connections. See Pipe, Iron, ¼ Curve.

PIPE, IRON, ¼ CURVE. A special short length of pipe, cast to a 90 deg. bend with suitable ends for connecting two standard lengths of pipe. It is also commonly called an elbow, or a 90 deg. bend.

If not otherwise specified ¼ curves for bell and spigot pipes up to and including 12 in. diameter are furnished with two bells. Larger sizes are usually

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furnished with bell and spigot. Special ¼ curves are sometimes made with straight extensions a few inches long at one end. Another style is made with a base casting designed as a support.

PIPE, IRON, OFFSET. A length of pipe including a reverse curve and opposite end connections suitable for the continuation of a line of pipe in a line parallel to its beginning. Offsets are frequently made up of standard bends oppositely placed to form reverse curves.

PIPE, IRON, PLUG. An end casting designed to be secured inside a pipe to fill the aperture except for one or two small taps, usually furnished for small pipe lines. Thus a 30-in. diameter plug may have taps for a 2-in. pipe and a 3-in. pipe.

PIPE, IRON, REDUCER. A short tapering pipe casting designed to connect two pipes of different diameters. The entire length excepting the connecting collars of one style of reducer is a tapering length of pipe with plain converging walls. Another style of reducer is bottle shaped, the taper being made by short curves producing a shoulder in the middle of the casting.

PIPE, IRON, SLEEVE. A short length of pipe designed to hold together the ends of two pipes which fit inside it, the sleeve ends being shaped to form suitable joints. A common style called a split sleeve is composed of two flanged halves designed to be bolted tightly together around the pipe ends.

PIPE, IRON, STANDARD CURVE. A bend of 1/8, 1/16, 1/32 or 1/64 is a standard casting in cast iron water pipe.

PIPE, IRON, TEE. A pipe connection designed to join a through pipe line with another at right angles thereto and ending at the tee, which is commonly furnished with a supporting base and with bell and spigot on the run. The right angle branch aperture of a tee may be of a diameter corresponding to the opposite main apertures or it may be smaller.

PIPE, IRON, Y BRANCH. An iron casting providing for two lines of pipe equally diverging from one larger line, or for one diverging and one straight line. The angle between the two branches is commonly 45 deg.

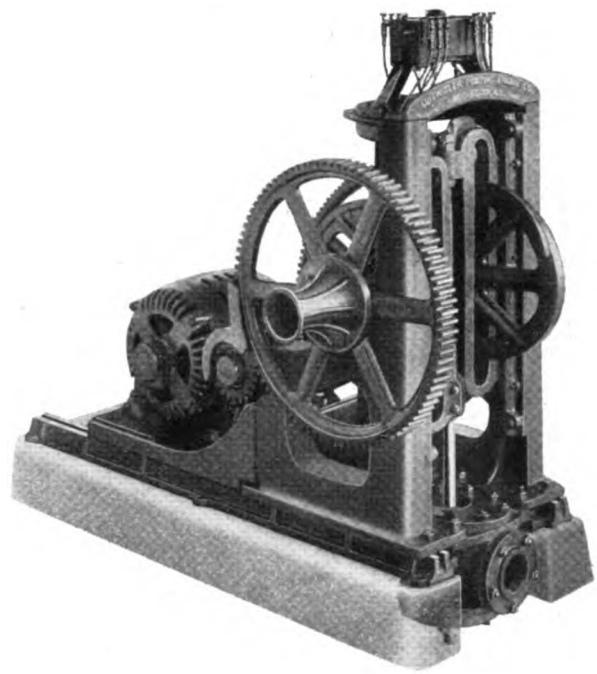
PISTON, PUMP. A disc or cylindrical device designed to fully occupy the section of the cylinder or working barrel of a pump while it is moved forward and back, usually up and down, within the cylinder under pressure for the purpose of lifting water. The pistons are the essential parts of the pump, since by their reciprocating action the water may be lifted in a continuous stream. See Pump.

POT, LEAD POURING. A round iron pot in which lead is melted, usually by means of a gasoline torch. Lead pouring pots are commonly made about 6 in. to 8 in. deep, the bottom being somewhat flat with slightly rounded sides while the top has a lip spout and a wire bale with a hook at the top. Near the bottom of the pot and on the side opposite the spout, is a small hook by which the pot is tilted to pour the contents. These metal pouring receptacles vary from 5 in. to 12 in. in diameter and hold from 12 to 130 lb. of lead. They are used in joining water pipe with bell and spigot ends, in soldering, etc.

Solder Pouring Pot

PRIMING (Boiler). The sudden rising of wet steam from the heating surface which so agitates the water that it is thrown up into the steam space as indicated by the restless action of the water in the gage glass of the boiler. Priming may be the result of suddenly opening the throttle and can be controlled largely by proper handling of the engine. Commonly the results of priming are momentary and similar to the action produced by foaming, which on the other hand is persistent and thus easily detected by the operator. See Foaming (Boiler).

PUMP. A machine for raising water from wells or other sources of supply, usually into elevated storage tanks, from which it may be lowered by gravity into locomotive tenders through delivery devices as required to provide steam for operating locomotives. The essential parts of such a pump are one or more pistons, plungers, fans or the like, with or without valves, moving in or in correlation with one or more pump stocks, barrels, chambers or other enclosed spaces. The pump is operated by means of a power unit which may be integral with or separate from the device which moves the rods and pistons or other water-lifting machinery. Duplicate power and pumping units are sometimes installed at important stations to insure continuity of supply. The type of pump and power unit vary with local conditions, as the elevation of the source of supply, its distance from the storage tank, the amount of water consumed, etc. Preferably the pump and its engine are placed within a few feet of the water to be lifted or as close as possible, to facilitate priming and avoid the leakage of air into the suction pipe with consequent loss of power or suction head.


Electrically Operated Deep Well Pump
The Luitwieler Pumping Engine Co.
(See Page 738)

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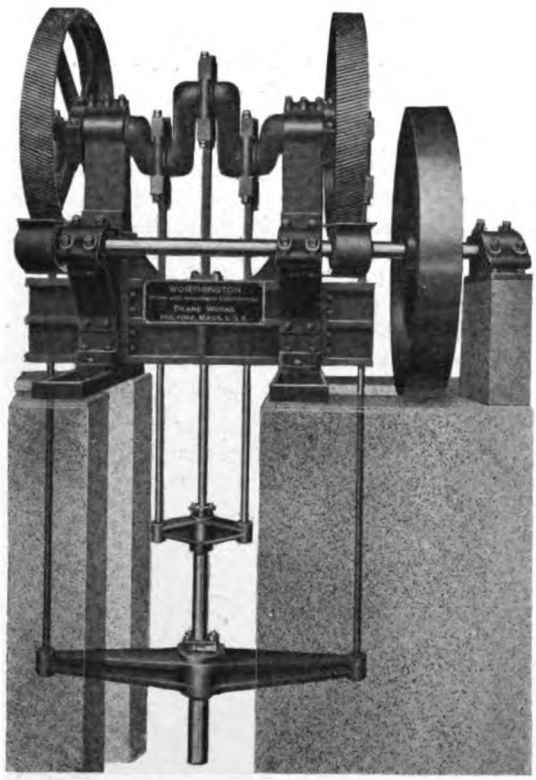
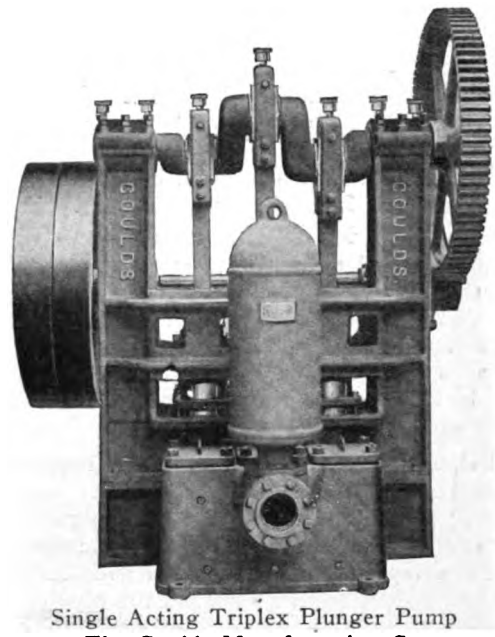
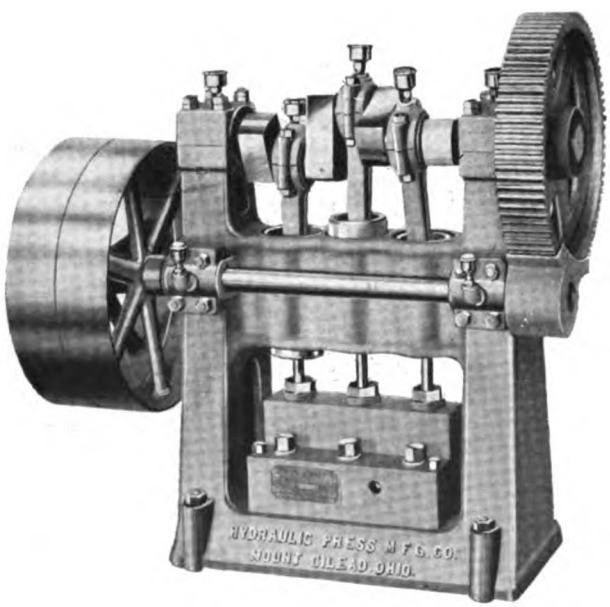


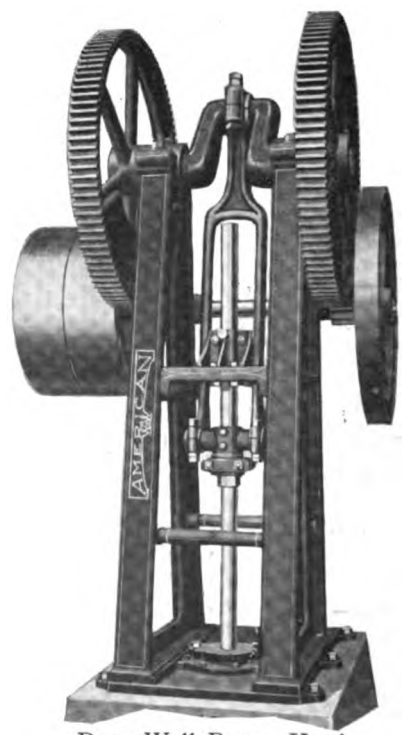
Glendora Triple-Plunger Deep Well Head
The Worthington Pump & Machinery Corporation



Single Acting Triplex Plunger Pump
The Goulds Manufacturing Co.



Vertical Single Acting Triplex Hydraulic Pump
The Hydraulic Press Manufacturing Co.



Deep Well Power Head
The American Well Works

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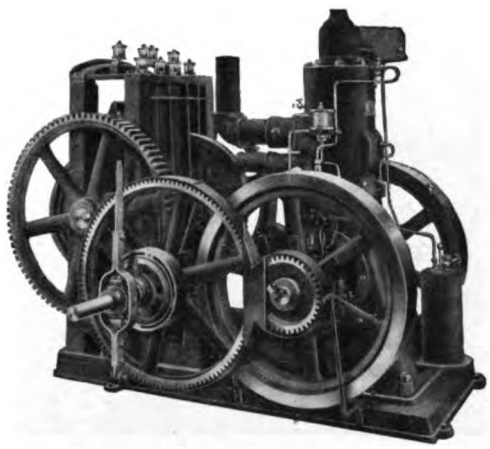
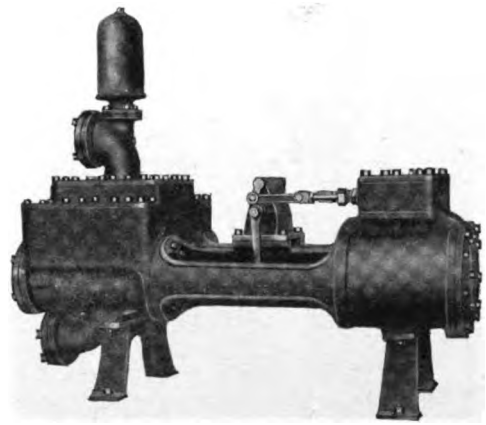
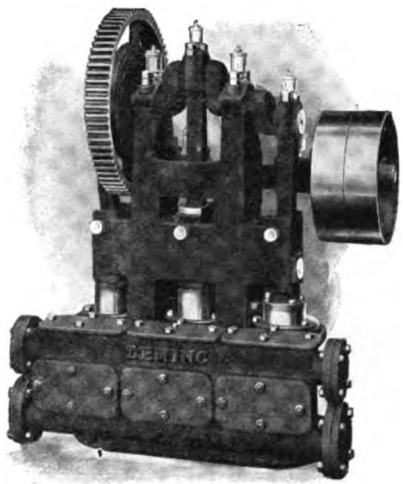


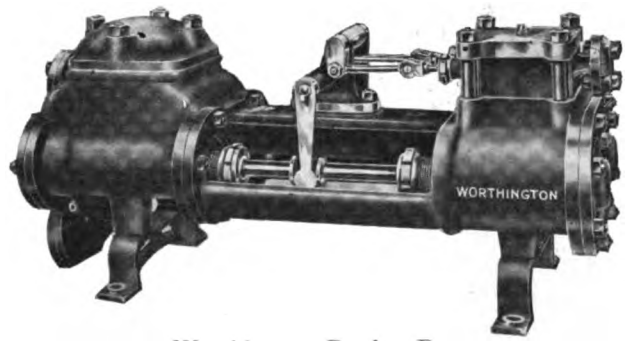
Deep Well Power Head Operating on Fuel Oil
The Luitwieler Pumping Engine Co.
(See Page 738)



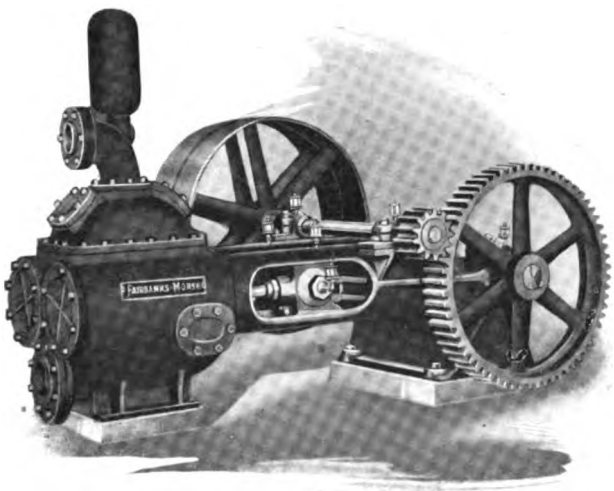
Wagener Duplex Pump
The Wagener Steam Pump Co.



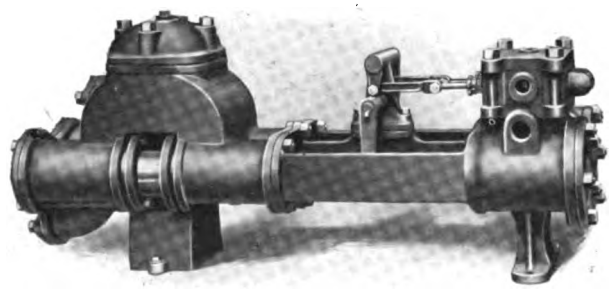
Deming Single Acting Triplex Plunger Pump
The Deming Co.



Worthington Duplex Pump
The Worthington Pump & Machinery Corporation



Duplex Plunger Pump
Fairbanks, Morse & Co.
(See Page 686)



Duplex Plunger Pump
The John H. McGowan Co.

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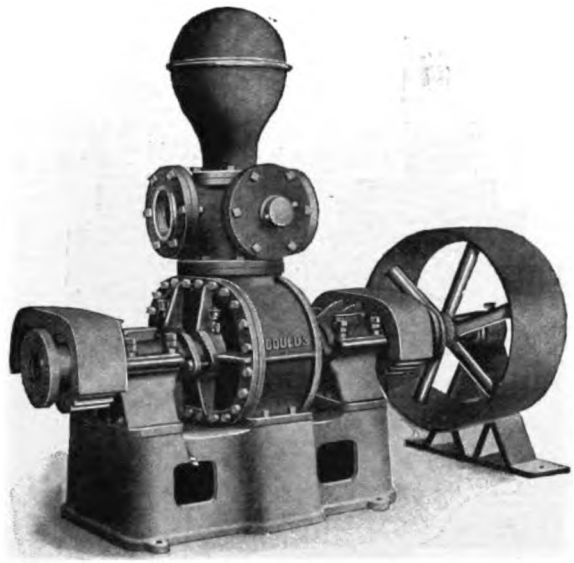
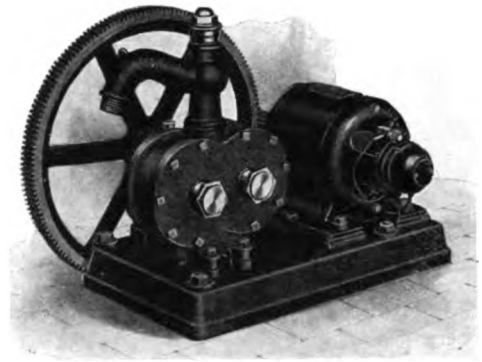
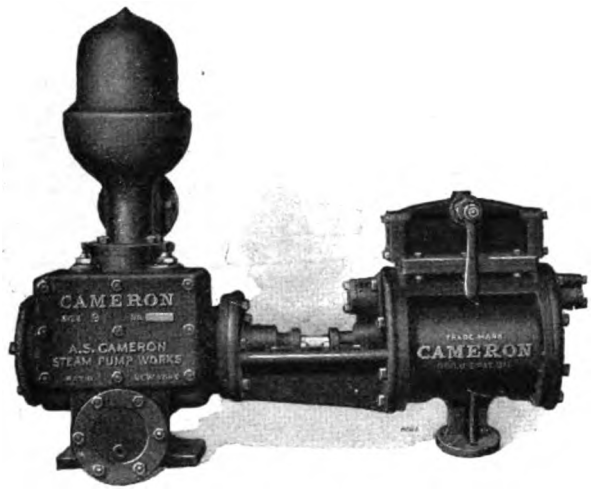


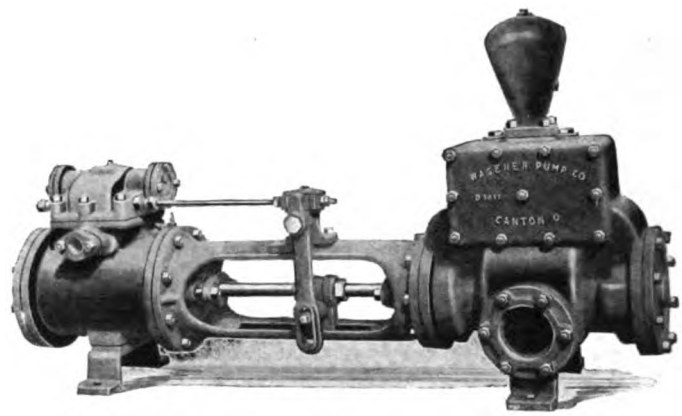
Belt-Driven Rotary Pump
The Goulds Manufacturing Co.



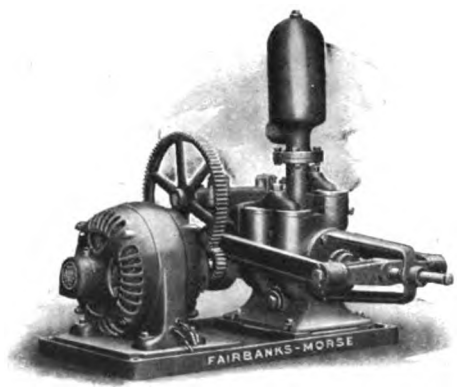
Deming Rotary Force Pump
The Deming Co.



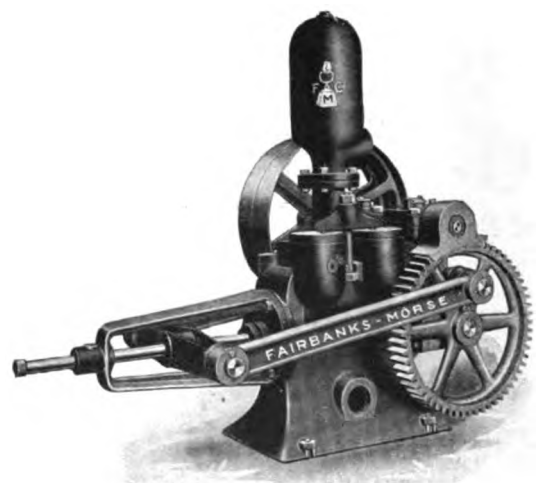
Cameron Simplex Pump
The A. S. Cameron Steam Pump Co.



Wagener Simplex Pump
The Wagener Steam Pump Co.



Motor-Driven Typhoon Pump
Fairbanks, Morse & Co.
(See Page 686)



Typhoon Double Acting Pump
Fairbanks, Morse & Co.
(See Page 686)

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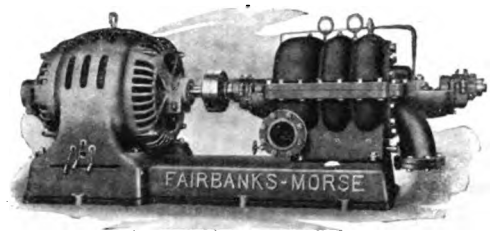
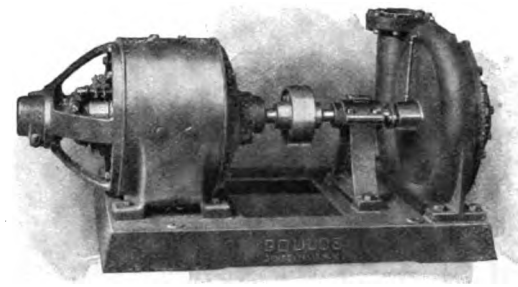
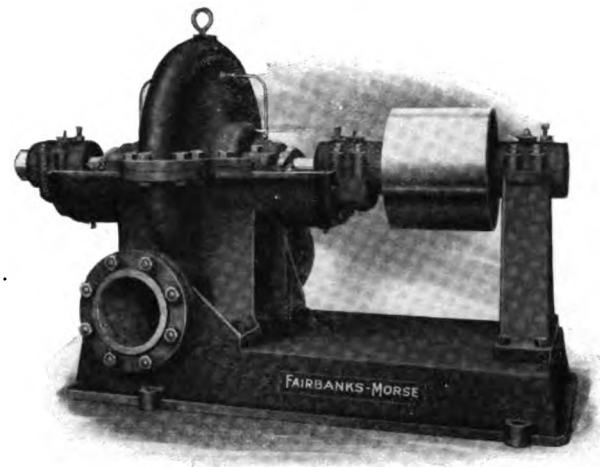


Motor-Driven Centrifugal Pump
Fairbanks, Morse & Co.
(See Page 686)

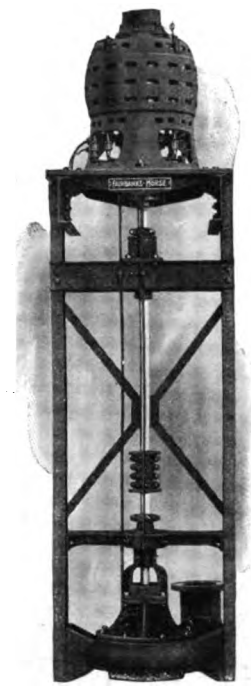


Goulds Centrifugal Pump
The Goulds Manufacturing Co.

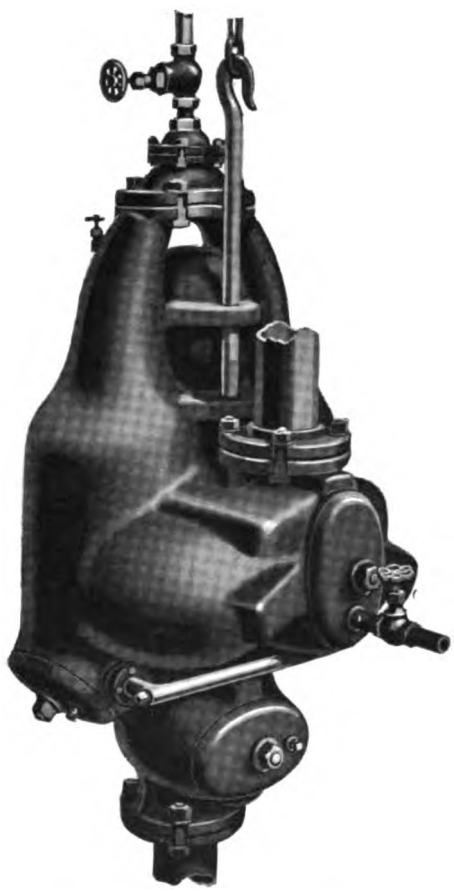


Horizontal Centrifugal Pump
Fairbanks, Morse & Co.
(See Page 686)

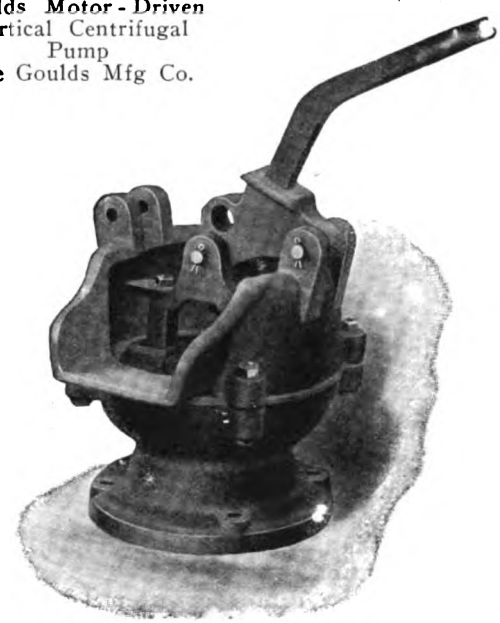
Goulds Motor-Driven
Vertical Centrifugal
Pump
The Goulds Mfg Co.



Motor-Driven Vertical
Centrifugal Pump
Fairbanks, Morse & Co.
(See Page 686)



Pulsometer Pump
The Pulsometer Steam Pump Co.



Diaphragm Pump
The Deming Co.

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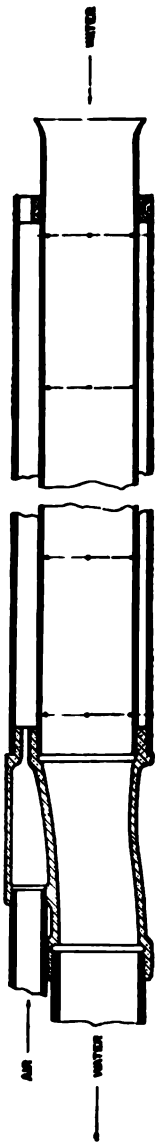
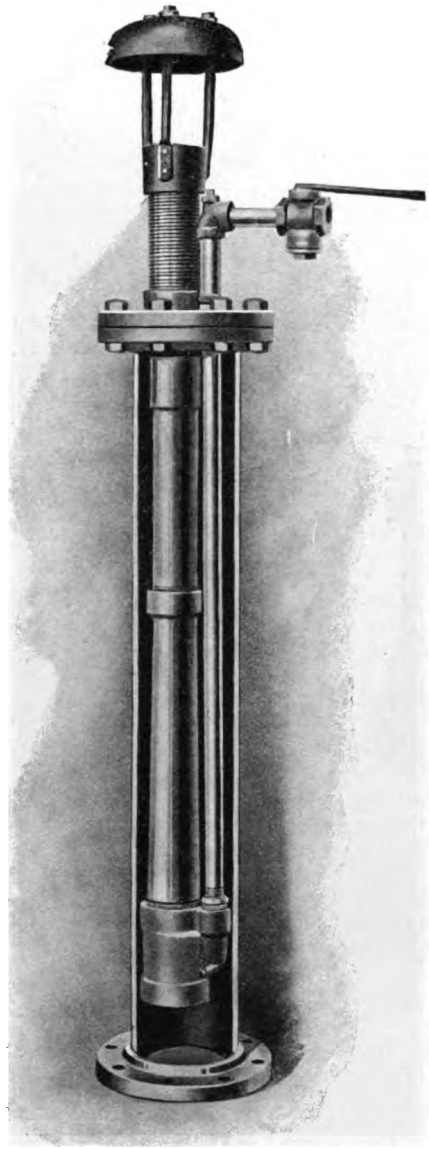
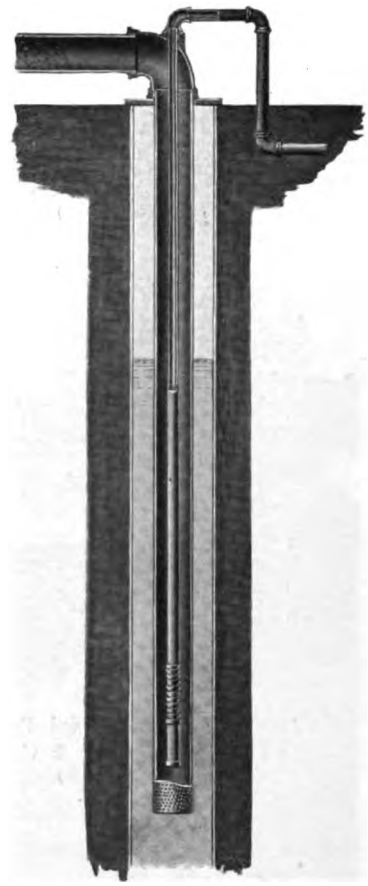


Sketch of the Imperial Air Lift Pump
The Ingersoll-Rand Co.



Sullivan Air Lift Foot Piece and Umbrella Well Top
The Sullivan Machinery Co.



Air Lift Pumping Plant

Pumps are divided into three general classes according to the service required; (1) suction pumps, (2) lifting pumps, and (3) force pumps. There are two types of force pumps, (a) single acting and (b) double acting, the action depending on the manner in which they take water, whether on one or both sides of the piston. Force pumps are known as simplex, duplex or triplex according to the arrangement of their cylinders. As pumps displace the water in various ways, they may also be classified according to the method of displacement, into reciprocating, centrifugal and rotary types.

PUMP, AIR LIFT. An installation for introducing air in thin streams into the column of water in a well, thereby imparting to the water a buoyancy which causes it to rise. This device consists simply of a vertical pipe for water and a pipe for air. These pipes are placed inside of a well with the smaller air pipe either inside or outside of the water pipe, and are submerged to a depth proportional to the lift when the pump is in operation. Unlike an ordinary compressed air pump in which the air pushes and forces the pistons to lift a column of water, compressed air is forced down the well through the air pipe to a proper point and allowed to escape in the form of jets into the rising main. The mixture of air with the water causes the water to rise on account of the buoyancy of the mixture and the expansion of the air bubbles aided by the greater weight of the solid column of water surrounding the rising main or discharge pipe. A feature of this process is the purifying of the water through aeration. Air lift pumps are adaptable especially to a central station supplying power to a number of wells widely distributed and discharging water into a common delivery line over a considerable area from which sufficient water is unobtainable from any one well. There are usually no movable parts of an air lift pump in the well nor are they susceptible to clogging on account of sand, etc. Their use in railway supplies is commonly limited to areas not adaptable to development from a single well of extensive capacity. See Pump.

PUMP, CENTRIFUGAL. A valveless pump in which the moving part is a revolving wheel or fan with curved vanes or spokes, encased in a steel shell; the water being admitted at the center of the fan, and carried around by centrifugal force to escape from the tips of the blades into the discharge pipe.

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These machines are either vertical or horizontal with single or double suction, directly connected or belt driven, depending primarily on the power unit and are designed to be placed as conditions demand on the surface of the ground or below the surface of the water.

The ordinary vertical type is designed to be placed on the ground or below the surface of the water supply and driven by a power unit. Sometimes the difference between high and low water, as in a river or deep well, is as much as 30 ft. or more in which case the pump may be dropped to obtain a short suction at low water stages where it will operate satisfactorily when submerged during high stages.

A horizontal type of pump which has a bottom suction and vertical shaft is used for this service and is driven by power placed at the surface of the ground. Any centrigual pump may be of the single or multiple stage type; that is, there may be one or more fans or wheels fastened to the shaft in the shell, depending on the lift and the nature of the work to be performed. The single stage pump is more commonly used in railway service, especially in open wells. An advantage of centrifugal pumps is that they have no valves and are therefore not easily affected by sand or sediment in the water. See Pump.

PUMP, DEEP WELL. A pump designed to lift water from a well in which the surface of the supply is so far below the top of the ground that the cylinder with its pistons and valves must be lowered inside the casing to the water, while the power unit and the machinery used to raise and lower the pistons by means of rods, are located at the top of the well. Inside the casing of a deep well are placed the working parts of the pump, consisting of the cylinder, the working rod and the plunger or bucket piston, which is raised and lowered by a steam or power head placed directly over the well and driven by a power unit. The lower or fluid end of a deep well pump may be of the single-acting type of working barrel or it may have several reciprocating pistons.

A single acting pump, that is designed to lift water on the upstroke only, consists essentially of a working rod terminating in a plunger or a bucket piston working in a cylinder, all placed within the well casing.

Another type of deep well pump has two pistons and two piston rods, one rod moving within the other in the drop or column pipe, while the well head consists of an upright cast iron frame supporting the crank shaft and pinion shaft by which the pump is driven. The connection between the power head and the fluid end consists of two metal piston rods, an outside tubular piston rod attached to the crossyoke and an inside solid rod attached to the center crosshead. The three connecting rods driven by the crank shaft are fitted at their lower ends to crossheads, of which the outer two drive the crossyoke. The working barrel contains the two plungers, each of which is driven by one of the two piston rods forming the connection with the well head. Another type of deep well pump having three instead of two plungers and operating in the same manner as the two-plunger type is sometimes used in railway locomotive water stations. The advantage gained with three plungers is the readiness with which a steady flow may be delivered with more perfect balance and distribution of load among the rods. See Pump.

PUMP, DEEP WELL, POWER HEAD. A power machine located directly over a well and consisting essentially of a counter shaft carrying (1) the pinions which mesh into the driving gear on the crank shaft, (2) the pulleys for the belt drive, motor gears or clutch, depending on the method used to transmit power from the power unit to the head, (3) a crank shaft carrying the driving gear, (4) one or more cranks by means of which a reciprocating movement is transmitted to the pump rods, through a cross head working in guides; the shaft being mounted on an iron frame secured to the bed plate or foundation. See Pump, Deep Well.

PUMP, DEEP WELL, STEAM HEAD. A vertical steam cylinder mounted on a frame with pump rods connected direct to the piston.

This machine is designed to be placed directly over the well on a suitable masonry or timber foundation while the drop or column pipe which sustains the water cylinder in the well is screwed into the toe head at the base of the pump, the weight of the pipe holding the pump in place. See Pump, Deep Well.

PUMP, DUPLEX. A double acting pump designed to raise a continuous stream of water by means of reciprocating pistons. It consists of horizontal steam and water cylinders fastened to the opposite ends of a segmental iron or steel frame which acts as a guide for the piston and valve rods. It is similar in general design to the simplex pump except that in place of single steam and water cylinders it has two parallel steam cylinders and two parallel water cylinders in which the pistons operate alternately to exert a continuous force. Sometimes these pumps are belt driven and when so arranged the steam cylinders are replaced by a steel shaft set squarely across the frame. A fly wheel and a toothed gear wheel are fastened on the opposite ends of the shaft by means of which the pump is operated. See Pump.

PUMP, FORCE. A pump by which water is forced from the cylinder into the discharge pipe. This apparatus usually employed in the more powerful styles of hand pump and also for small power pumps where the lift is not more than 25 ft., is similar in design to the suction type of pump, except that the discharge pipe is located at or near the bottom of the pump cylinder and the piston is solid. The operation of this type of pump differs from the lift and suction types in that as the piston ascends, the atmospheric pressure on the surface of the water in the well forces the water up through the valve at the top of the suction pipe into the pump cylinder, whence it is forced through the discharge pipe by the piston on the downward stroke, thus completing one cycle of operation. A check valve at the bottom of the discharge pipe prevents the water from returning to the cylinder and only opens as the piston descends to force water from the cylinder into the discharge pipe. See Pump.

PUMP, PULSOMETER. A device for pumping water by means of the direct pressure of steam on the surface of the fluid in the chambers. This device is a double-chambered, vertical type of general utility

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pump without pistons or plungers, designed to be easily raised or lowered into a sump or well and to operate as efficiently while suspended from a chain as when permanently installed. The steam enters the chamber from the top through a slide valve, while the water enters through the suction pipe at the bottom. As the steam passes into the chamber filled with water the pressure becomes so great that the water is forced out into the second chamber and thence into the discharge pipe. But at the moment the water falls to the level of the opening leading into the second chamber, the steam and water mix, causing condensation of the steam. This forms a vacuum in the first chamber which shifts the slide valve, shutting off the steam supply and draws up a new charge of water through the suction pipe. While the first chamber is filling, the second chamber is emptying. This action completes one cycle of the operation which continues while power is furnished. See Pump.

PUMP, ROTARY. A pump the working part of which is a revolving shaft to which are secured discs or cams, which are in close contact at two or more points with the walls of the enclosing chamber or shell. This type differs from the centrifugal pump in that the fluid is continuously scooped out of its chamber or shell and into the discharge pipe, while in the centrifugal type the velocity is imparted to the stream of liquid by means of a fan or impeller. See Pump.

PUMP, SIMPLEX. A pump consisting of a single horizontal steam cylinder and a single water cylinder secured at opposite ends of a skeleton frame which acts as a guide for the connecting rods and pistons working in the cylinders. This type of machine, commonly used as a boiler feed pump, is direct acting and steam driven, suitable for discharge pressures not exceeding 150 lb. per sq. in., the water being intermittently delivered to the discharge pipe only on the forward strokes of the water piston. See Boiler Feed, Pump (Locomotive Water Supply).

PUMP, SUCTION. A pump which acts by creating a vacuum in the suction pipe in order that it may be filled with water by atmospheric pressure, after which the water is lifted through valves in the piston to the discharge pipe. This device consists of a cylinder or working barrel in which a piston or bucket is connected to a well head by a connecting rod.

The piston operates to lift water by creating a vacuum in the suction pipe as it rises on the up stroke, the atmospheric pressure on the surface of the water in the well causing the water to rise in the suction pipe. As the water rises in the pipe it lifts a valve at the top and fills the empty space in the cylinder caused by the displacement of the piston. When the piston reaches the end of the up stroke the water has entirely filled the space between the bottom of the piston and the bottom of the cylinder, as well as the suction pipe. As the piston starts on the down stroke, the water in the cylinder forces the valve at the top of the suction pipe to its seat and passes upward through the valves in the piston into the upper portion of the cylinder. When the piston reaches the end of the down stroke and commences the up stroke, the flow of the water through the piston valves ceases and the valves close. The water is then lifted by the piston on its up stroke and delivered through the discharge pipe. These movements complete one cycle of operation. This type is usually limited to hand operation, an example being the common house pump. See Pump.

PUMP, TRIPLEX. A hydraulic machine for lifting and transferring water from the source of supply to a higher storage tank. This machine consists usually of two upright, parallel, A-shaped, steel columns framed to support between their tops the ends of a horizontal crank shaft carrying the crank pins of the cylinder connecting rods and a toothed gear wheel; while across the front of the frame is placed the horizontal pinion shaft, the pinion gear being so secured at one end of the shaft as to mesh with the larger toothed gear wheel on the crank shaft. The machine is driven by a fly wheel, also fastened to and revolving to operate the pinion shaft. The crank pins of the three connecting rods are placed on the crank shaft in planes at angles of 120 deg. apart, by which arrangement the reciprocating strokes result in continuous action upon the water being pumped, insuring a uniform flow through the delivery pipe. The fluid cylinders are usually placed on or just above the steel base of the machine unless the suction is too long, when they are dropped to the position that gives the maximum efficiency.

These machines may be either single or double acting, and are so designed that the plungers or pistons are always submerged, thus keeping the pump primed at all times and enabling it to work on long suction lifts. Single acting triplex pumps have outside packed plungers, the water in each cylinder being displaced once during every revolution of the crank shaft, while the double acting type has inside packed plungers, the water displacement taking place on both the up and down strokes, or twice during each revolution of the crank shaft. Otherwise the single and double acting pumps conform in general design. While triplex pumps are usually vertical they are also made in a horizontal type, sometimes mounted on a steel frame resting on small flanged wheels for emergency or temporary use. Triplex pumps are designed to be operated by electric motors, gas, gasoline or steam engines, either belt driven or directly connected to the driver, for use in railway water supply service where high pressure is necessary to supply water to elevated tanks or reservoirs. See Pump.

PUMP, VERTICAL STEAM. A pump driven directly by steam in which the steam pistons and pump are usually on the same rod. See Pump.

R

RUNOFF. The water which finds its way into streams, etc., from the surface of the ground on which it first falls as rain or snow. A part of the rain or snowfall evaporates while more seeps into the ground. The remainder which flows into streams composes the runoff.

S

SCREEN, PUMP. A tubular strainer of non-corrosive metal designed to be attached to the bottom of the suction pipe of a pump with a view to

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preventing sand, etc., from entering with the water and clogging the pump valves.

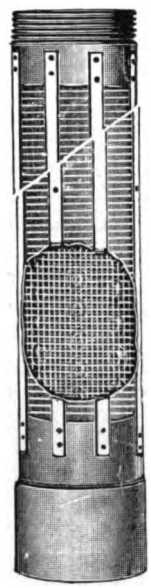
This strainer, screwed to the bottom end of the suction pipe, forms the lowest section and terminates sometimes in a drive point or in a special device for excluding sand. The cylindrical walls may be double with perforations so formed as to permit sand to separate from the water by gravity after passing the first wall and before passing the inner screen.

Foot Valve Strainer
The U. S. Wind Engine & Pump Co.

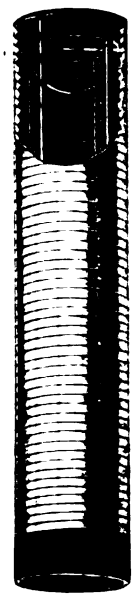
In wells where the current of water toward the well is strong enough to carry loose sand, gravel, soft stone or shale which constitute the water-bearing stratum, efficient screens are indispensable pump attachments, as it is impossible to prevent the valves from clogging without them. The remedy lies in slowing down the velocity of the current so that the solids settle before the water enters the pump. Sometimes violent pumping will raise the fine particles, leaving the screen surrounded with coarse gravel. If the stratum is all fine sand, an additional outside casing may be driven around the completed well, the space between the walls of the two casings being filled with coarse sand before the outside casing is removed. The fineness of the mesh and the number and arrangement of the strainer walls of a pump screen suitable for the exclusion of solids from the water vary with these local conditions.

When a well point is on bed rock the screen is usually in coarse water gravel, which is readily excluded, but if the point is in fine sand, special provisions, such as interior and exterior screens, are frequently used to prevent the sand from rising into the valve chambers. A typical tubular brass screen for deep well pumps is of metal hard enough to resist the cutting action of sharp sand, with slot apertures of less area at the outer surface than at the inner surface of the screen wall, and with discharge capacity based on the rate of flow required, which governs the length and design.

SCREEN, WELL. A non-corrosive metal strainer designed to be attached to a suction pipe to prevent the entrance of sand, etc., with the water through the pipe which may clog the pump valves. The screen may be designed only to exclude grass and fish from lake water; or particles of gravel from large pebbles to fine sand from a drilled well. Commonly this device is a tube of thin sheet metal (perforated with small round holes or parallel slots), suitably reinforced and sometimes supplemented by fine-mesh wire screen. It is usually designed to be attached to the fluid end of the pump where trouble is experienced from the suction drawing foreign matter into the pipe. The screen is sometimes supported by means of an attached float or otherwise to keep it free from the obstruction at the bottom, although low enough to be completely submerged; or it is placed in a protecting sump or box.



Deep Well Screen
The American Well Works



Johnson Brass Well Screen
Edward E. Johnson, Inc.
(See Page 723)

Johnson Pipe Brass Well Screen
Edward E. Johnson, Inc.
(See Page 723)

SEDIMENTATION. The process of causing particles of matter which are suspended in a body of water to settle to the bottom. Sedimentation is of interest in railway water service as a process by which muddy river waters are clarified in a settling basin or by which waters containing suspended matter as the result of chemical treatment are clarified in the water treating plant. The process of sedimentation may be supplemented by a filter or in the case of colloidal matter by the use of coagulants. See Filter. Also Coagulation.

SLUDGE. The sediment or coagulated matter which sinks to the bottom of a tank, especially as a result of chemical treatment to remove dissolved matter from the water.

Provision is made in some types of water tanks to collect sludge in a small area at the bottom of the tub where it may be flushed out of the tank by means of a blow-off pipe and valve.

SOLID, INCRUSTING. Matter held in solution which tends to form scale on the heating surfaces in a boiler when it is precipitated as the water evaporates or as a result of increased temperature. The most important of these substances are the carbonates of calcium and magnesium and the sulphate of calcium, which tend to form boiler incrustations after they have been precipitated by the heat and pressure to which the water is there subjected. These substances are found in hard water, which if very hard and used without treatment leaves sediment which hardens and adheres to the metal surfaces. This gradually restricts the capacities of tubes, sometimes causes corrosion of the steel and insulates the metal so that excess fuel is necessary to produce heat for evaporation.

SOLID, NON-INCRUSTING. The solid dissolved in water and not active in producing sediment

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or scale in the boiler as a result of evaporation. Non-incrusting solids are commonly understood to include the carbonates and sulphate salts of sodium and magnesium, which are the primary causes of foaming in boilers. Sodium chloride or common salt is also highly soluble and will not form scale. It does, however, furnish the saline solution for galvanic action which frequently corrodes the metal in boilers.

Sodium sulphate is similar in action but not so good a conductor of electricity. Sodium nitrate is extremely soluble, its only injurious effect in boiler water probably being to aid corrosion, corresponding salts of potassium being identical in behavior.

SPILLWAY. A low-level passage serving a dam through which surplus water may be discharged; usually an open ditch around the end of the dam, a gateway or a pipe in the dam opened by lifting a gate or opening a door or valve by means of machinery, sometimes automatic, with a view to lowering the water and thus reducing the pressure behind the dam and preventing the water from overtopping it. Since the descent from the watershed in a drainage area is steeper than the grade of its main waterway or channel, the tendency of the water is to carry a heavy sediment or wash which naturally settles in the pond or back-water behind a dam.

Spillways and sluice gates are used to overcome the pressure of surplus impounded water as well as the continually increasing quantity of silt deposited. The sizes and designs of these devices depend largely on the area, contour and soil of the district over which the water flows as well as on the climatic conditions. Spillways constructed of wood, steel or masonry are so designed as to pass a large volume of water from the dam in a short space of time, while gates may be made to serve the two-fold purpose of (1) relieving the back pressure, and (2) scouring off the silt deposits. A spillway generally consists of a sluice or box-like opening, usually placed near one end of a dam, the top being a little below the crest of the dam. It is commonly so designed that the apron extending through the dam has a fall sufficient to carry the water rapidly over its surface to a safe distance below the dam and away from the footings. Another type of spillway common to earth dams consists of an excavated passageway running around and away from either side of the dam. This type of spillway is used as an overflow for the passage of impounded water during stages of high water. Gate spillways commonly consist of heavy vertical wood or steel frames with solid liftable gates placed at intervals in the body of a masonry dam and are designed to be raised and lowered by hand or power machinery.

SPOUT, TANK. A movable delivery pipe so fixed to a water tank as to conveniently conduct water into the tanks of locomotive tenders. The spout is a slightly tapered tube averaging about 9 ft. long, 16 in. in diameter at the inlet end and 10 in. in diameter at the discharge end, where it is bent downward about 50 deg. like the elbow of a stove pipe to discharge water vertically into the tender tank when lowered. The tank spout is made of riveted sheet metal, commonly galvanized iron, and is attached to the side of the tank facing the track near or below the floor of the tub, by means of a hinge or a short chain at the back of the rim at the inlet end.

The hinge is preferably a swivel fastening which permits the spout to be swayed sidewise, while it is raised to its normal position by means of chains fastened to a collar about one-third its length

Galvanized Tank Spout
The U. S. Wind Engine & Pump Co.

Sway Spout
Fairbanks, Morse & Co.
(See Page 686)

back of the discharge end, passed over pulleys attached to the face of the tank and down to terminal counterweights heavy enough to lift the spout to the upright position when freed. It is pulled down to discharge water by means of a hand-hold attached to a short chain fastened to the under side of the collar, to which is also secured the end of a rope which on being pulled opens the discharge valve in the bottom of the tank, the bent discharge pipe or gooseneck leading the water into the lower spout. When the spout is raised any water that is still in it readily drains from the loose open joint at the inlet end.

STAVE. One of the upright long, narrow, dressed boards which, grooved for the floor joints and held tightly edge to edge by means of outside metal hoops, forms the hollow cylinder of a wooden water tank tub. See Tank, Wood.

SUSPENDED MATTER. Undissolved particles of matter floating in water and which may be removed by filtration, coagulation or sedimentation. It may be organic; that is, vegetable or animal matter, usually in a state of decay; or inorganic, such as particles of earth, or solids thrown out of solution through chemical action. See Filter.

T

TANK (Locomotive Water Supply). An elevated water tank or a standpipe erected in a location and at a height suitable for storing and delivering water conveniently to steam locomotives. Circular tanks are in general use on railways, and commonly range from 20 ft. inside diameter by 16 ft. high with a capacity of 50,000 gal. to 30 ft. inside diam. by 20 ft. high with a capacity of 100,000 gal. The tubs are built of pine, cypress or redwood, while cedar is also used for the staves and fir for the bottoms, sometimes treated with a preservative, or the tower or the entire structure is made of steel, or sometimes of reinforced concrete. They are roofed chiefly as a protection against freezing, while the substructures are commonly of materials similar to

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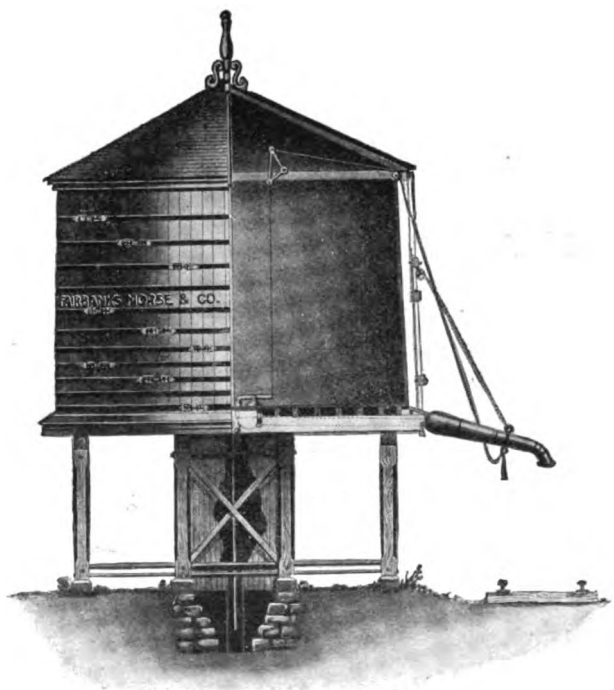
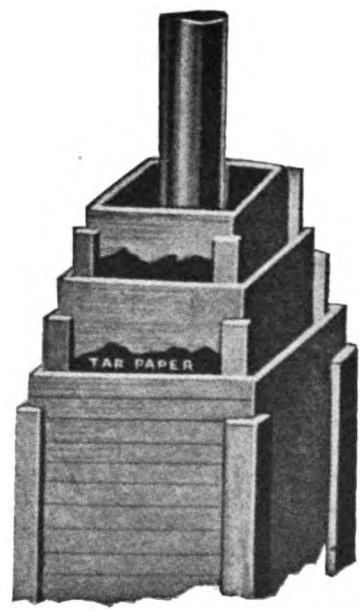
Water Tank with Windmill

Wooden Tank and Support
The U. S. Wind Engine & Pump Co.



Wooden Railway Tank
The Fairbanks, Morse Co.
(See Page 686)

Circular Front Frost Box



Square Front Frost Box

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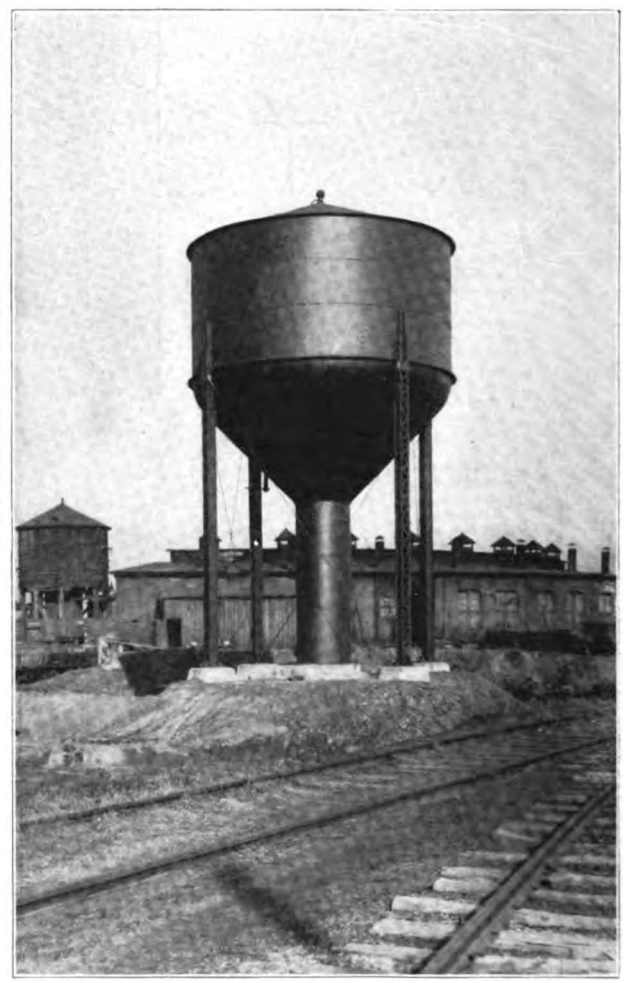
the tanks. The usual timber substructure for a wooden tank consists of parallel joints on caps supported on plumb posts which are braced diagonally with wood and horizontally with round steel rods, while their foundations are concrete footings. The

Elliptical Bottom Tank
The Chicago Bridge & Iron Works
(See Page 664)

steel tank substructure is commonly a trestle of fabricated steel on concrete footings, while the reinforced concrete tank is usually set on a substructure of concrete, heavily reinforced with steel.

The reinforcement of the tubs of all tanks against the pressure of the water they contain is of wrought iron or steel. The flat, round, half-round or half-oval metal hoops of a wooden tank are usually made in two or more sections, provided with tightening lugs and bolts. The dimensions of tanks are limited largely by the weight of the contents, and by the high comparative costs of large tanks as against the duplication of units of 50,000 gal. to 100,000 gal. capacity. The water is usually forced into the tank through an upright iron pipe centrally located beneath the structure and protected from frost by an insulated frost box built around it. An outside indicator weight, attached to a line fastened to a float valve inside the tank shows the height of the water in the tank by its position on a vertical foot-marked indicator boat. Where an electric pump is installed, the float valve is sometimes attached to a circuit-breaker to stop it automatically when the tank is full and to start it when the supply is lowered. The discharge pipe of a direct delivery tank is also located in the floor of the tank on the track side, with a valve at its top which is operated to open or close it by means of a vertical rod attached to a lever on and overhanging the roof, with a chain suspended from the depending end, which the operator on the locomotive tender may pull to open and release to close the delivery valve.

The sway spout is a slightly tapered galvanized iron or steel water-delivery pipe about 6 ft. long with a downward terminal outlet bend, and with a pivot hinge at the back of the inlet end which secures it to the front of the tank, while a line, a pulley and a counterweight are arranged to lift or lower it. When the spout is lowered to deliver water the open base fits loosely about the projecting horizontal end of the gooseneck outlet pipe of the tank, forming an effective open delivery joint from which all water drains readily when the spout is again lifted to the closed position.



Conical Bottom Tank
The Chicago Bridge & Iron Works
(See Page 664)

Indirect delivery of water is made from elevated or standpipe types of storage tanks through the tank outlet pipe which usually leads the water down through the central riser or frost box to a right angle bend which forms its connection with the underground pipe line serving the roadside water columns. Between the base of the outlet pipe and

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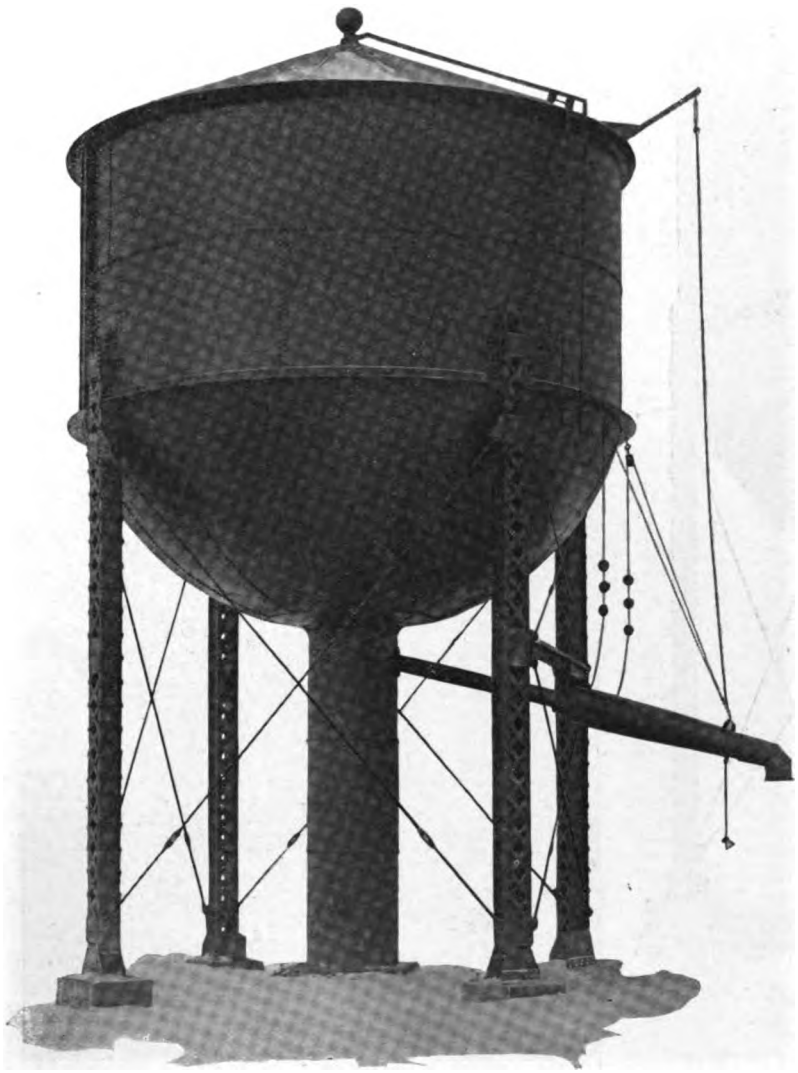
the water column delivery line is a valve box designed to afford access to the control valves which govern the storage and water column supplies. This valve box is commonly beneath or close to the base of the storage tank, placed well below the frost line and carefully protected to prevent the water from freezing. At the end of the delivery line is another underground valve box at the base of the water column where the delivery valve is located. When the lever at the upper end of the rod or other controlling device is pressed by the operator on the locomotive tender, the valve opens to discharge water and closes when the device is released.



Four Post Steel Railway Tank
The Pittsburgh-Des Moines Steel Co.
(See Page 774)

The foundation for the trestle substructures of elevated wood or steel tanks are sometimes composed of two piles under each plumb post, of which there are twelve in the ordinary trestle, one at each corner of the central frost box and eight under the circular rim of the tank. Usually the foundations are of masonry and when the ground is soft they are set on piling, two or more piles forming the support of each concrete footing, which is about 2 ft. square at the top and 3 ft. 6 in. square or larger at the bottom, depending on the bearing power of the soil and the depth necessary to get below the frost line. The tops of the footings are usually at the level of the tops of the running rails when the tank is designed for direct delivery. The riser pipe extends downward to the floor of the frost box, where a bend connects it with a horizontal pipe which passes out of the side of the box, usually through an 18 in. opening in the masonry. A wooden frost box designed to protect the water against feezing at temperatures as low as 40 deg. below zero commonly consists of a square shaft enclosed on each of its four sides by a partition consisting of six parallel walls of timber separated by five 2 in. air spaces. Each wall is made of two 1 in. thicknesses of lumber with a layer of insulating felt between. A refrigerator style door about 3 ft. wide by 4 ft. high provides convenient access to the interior above the ground level. The tank floor is made of 3 in. by 10 in. dressed lumber fastened with ¾ in. dowels.

The height of the floor of such a tank is commonly about 20 ft. above the top of the rails, although this height is varied to accommodate the heights of the locomotives served.

Steel towers for elevated wooden tanks may have 8½ in. by 8½ in. angle posts with 3½ in. by 3½ in. by ⅜ in. angles for diagonal braces while the girders are usually 12 in. 31½-lb. I-beams, with 8 in. 18-lb. I-beam overlays. Steel posts are usually set on steel base plates placed on the tops of the masonry footings while wooden tower posts, sometimes set on vertical dowels protruding from the footings, are preferably placed on castings furnished with drain grooves and secured on the footings. The usual supporting tower of an elevated steel tank consists of the central riser and four equi-distant upright steel lattice columns fastened at their tops to the outside of the lower section of cylindrical plates and connected by means of diagonal rod or lattice braces. The masonry footings of the columns surround the masonry base and the valve box located beneath the bottom of the central riser.

Concrete Tanks

Reinforced concrete is sometimes used for elevated railway water tanks as well as for standpipe storage tanks. While tanks of this class of material are fireproof, have great durability and are economical to maintain, they are immovable and more expensive in first cost than the less permanent types. A difficulty of construction is the high class of workmanship and the careful selection of materials required. The shrinkage of the concrete necessi-

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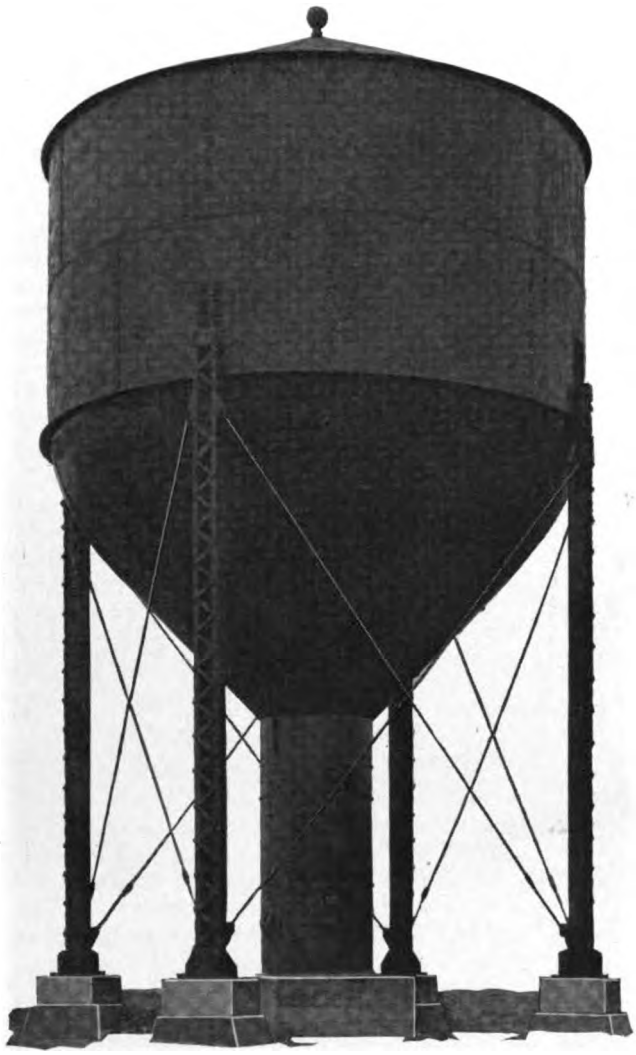
tates designing such tanks with concrete shells 4 in. or more in thickness and with low stressed steel reinforcement, with a view to minimizing shrinkage cracks through which water might find its way and which might be opened through the subsequent action of frost.

The concrete standpipe is simpler to construct than a tank on a tower and less expensive for railway service, considering the piping, frost proofing, etc.



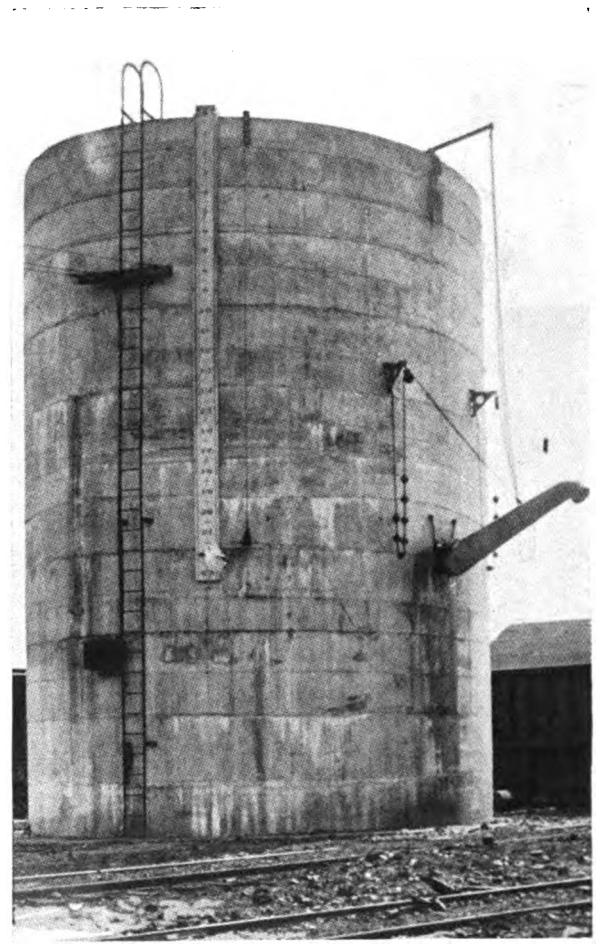
Sphericonical Steel Railway Tank
The Pittsburgh-Des Moines Steel Co.
(See Page 774)

The substructure of the elevated concrete tank as generally designed includes an octagonal foundation slab supporting the central riser pipe on which the octagonal deck slab rests.

Steel Tanks

Metal water supply tanks are made of riveted steel tubs set on fabricated steel towers, or sometimes of simple steel cylinders. The elevated steel types are designed for the storage of water to be delivered to locomotives through water columns as well as for roadside tanks with direct delivery spouts, while the standpipe is a special type used only for indirect delivery by means of water columns.

While the relative dimensions and the capacities of elevated steel tanks are about the same as those of the wooden types, there are marked differences in design, the steel tanks commonly having elliptical, hemispherical or conical bottoms and large riveted steel risers or upright central tubes, which may be cylindrical or slightly conical. The principal uses of the riser are to replace the small diameter inlet and outlet pipes and to supplement the concave bottom of the tank as a receptacle for sediment which concentrates at the base of the riser from which it is drawn off by means of the sludge valve and the force of the water emitted when it is opened. The tub, usually of two or sometimes three sections of riveted steel plates, is commonly covered with a flat conical steel roof, supplemented by an inside wooden roof in cold climates where an insulated frost box is also sometimes provided inside



Concrete Tank
Fairbanks, Morse & Co.
(See Page 686)

the large central riser, which contains the inlet and outlet pipes and a blow-off valve. In some cases the riser, which helps to support the tanks, is provided with a false bottom beneath which a stove is placed, the heat rising through an annular air space to prevent the water from freezing in the riser and the tank.

Both the inlet and outlet pipes extend upward several feet above the bottom of the riser with a view to separating the water supply from the sediment. The concavity of the bottom of the tank also

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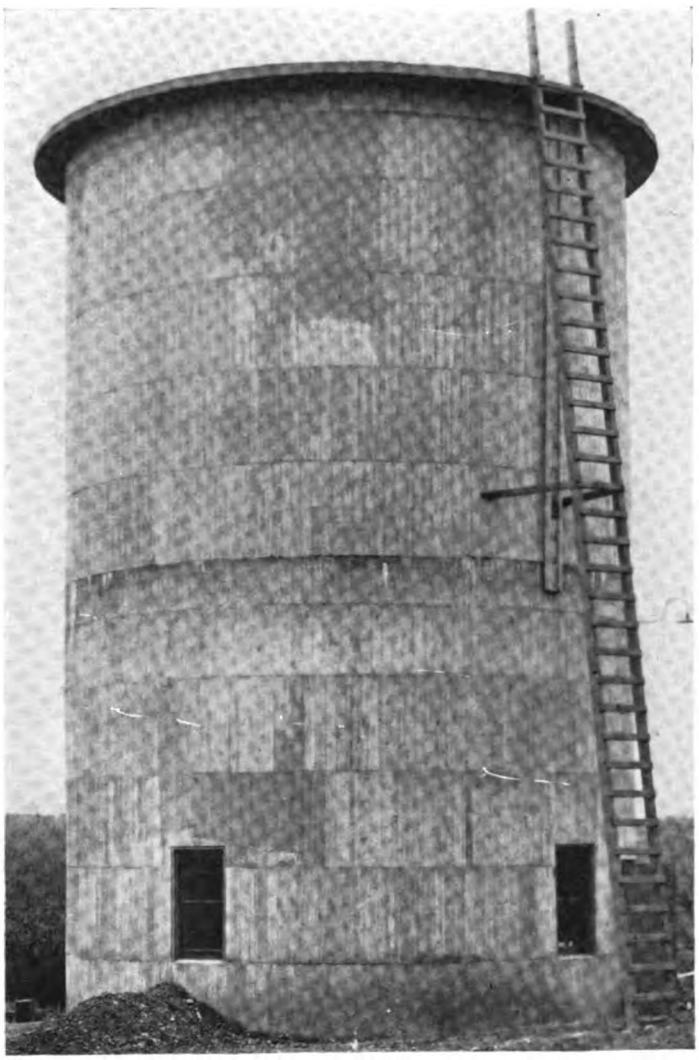
aids in concentrating the sediment, while a circular fender is sometimes placed in the bottom of the tank about the top of the riser to prevent ice from clogging the pipes. The steel plates of the tank, which are from ¼ in. to ⅝ in. in thickness, are of open hearth steel punched for rivets and then beveled on all edges for caulking before being bent cold to their finished forms.

The diameters of the successive sections of cylindrical shell plates alternate to fit in and out from course to course of the tank. Lap joints are generally used for all seams and splices excepting those which are vertical with plates more than ⅜ in. thick, when double butt joints with inside and outside straps are used. The riveting and caulking are preferably done with compressed air, no other means than calking being used to make the riveted structure water tight, the caulking being done preferably from the inside with a close pitch.



A Common Design of Concrete Water Tank

Steel tanks and standpipes are fireproof, long-lived, can be built with provisions for economical additions in height for increased storage capacity, and may be arranged for use as combined water softener and storage reservoirs, the chemicals being put in at the bottom and the treated water drawn from the upper part through a floating intake. They also have comparatively large scrap value when dismantled.

The steel standpipe tank is a simple cylinder with a masonry base and a valve box placed below the frost line, equipped with inlet and outlet pipes, the latter connecting with the pipe line which terminates in water columns. It is made in various dimensions, frequently higher and of less diameter than other styles of like capacity, common diameters being 24 ft. to 29 ft. for standpipes 43 ft. to 60 ft. high. The roof, if any, is flat and conical, the top and bottom circumferences are reinforced by means of angle irons and the structure is commonly placed on a reinforced concrete base at a distance from the tracks and preferably at an elevation above them. A manhole with a flanged and bolted cast iron cover is usually placed in the bottom section, while the valve box from which the pipe line extends to the water columns is located beneath the floor line under the tank. From a depression in the tank floor, which is used as a settling tank, a valved pipe leads down and outward to carry off sediment.

The wooden tank has been used for storing water for locomotives from the early days of railway operation. The tapered staves commonly used with riveted hoops driven down on the taper until they are tight are not necessary with sectional hoops, adjusted by means of lugs and bolts, by using which it is feasible to maintain a truly cylindrical type of tank which is now coming into use, together with certain lesser improvements, such as staves with tops deeply channeled with a view to retaining moisture in the wood fibre when the tank is partly empty, to prevent the tendency to shrink.

The life of untreated wood stave tanks is conservatively estimated to average about 20 years, being limited principally by the decay induced by the severe moisture conditions to which all water supply tanks are subjected. Conditions of alternate dryness and dampness tend also to early decay in the substructure, especially where the timber surfaces are in direct contact. The selection of uniformly sound timber, usually pine, cypress, redwood, cedar or fir, and treatment with wood preservatives, are measures most in favor for increasing the service life of the wooden tank and its substructure. Wooden tanks are sometimes placed on fabricated steel towers. While the wooden substructures sometimes rest on wooden piles, more substantial footings such as reinforced concrete, are favored, especially for permanent plants.

The flat conical tank roofs, while commonly made of wooden shingles, are preferably of some fireproof material on account of the danger of fire from sparks from locomotive smoke stacks. The chief function of the roof is to protect the water from freezing,

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and in latitudes which have no extremely cold weather tanks are not usually roofed.

An advantage of the wooden type of tank is the readiness with which it may be repaired or moved and re-erected. Tank parts should be protected from the weather until erected to prevent shrinking, the best practice being to construct the entire tub in one day, or to get it near enough completed to leave it in safe condition over night. A light rope fastened with a staple near the top of each stave as it is erected is serviceable as a temporary hooping during the driving on of staves, which is preferably begun on the windward side of the structure, the joints between staves being alternated with the floor board joints, no vertical joint being closer than 1 in. to a horizontal joint. The staves are sometimes furnished with dowels to facilitate erection. If not doweled they are tacked together at the tops with lath or wood strips or are held with staples or dogs until the hoops are put around them, the last stave being planed to the width desired to complete the tub. When the staves are all in place, the hoops, previously laid out ready for use, are put on with not more than one lug on a stave to avoid distorting the tub by too much pressure on one side. Wetting the inside of a tank after erection by splashing water from a hose or broom helps to expand the staves and make the structure water tight. Calking between the staves or wedging in any joint is not allowable, as the tank is designed to be water tight without any such alterations. It should be filled with water as soon as possible after setting up, and painted outside, the hoops being first painted with red lead.

The following specifications for wooden tank tubs were adopted by the A. R. E. A. in 1920:

50,000 Gal. Tank

1. **Material.** The tank, consisting of staves and bottom plank, shall be made of cypress, redwood, white pine, or such other timber as may be specified by the engineer; and shall be sound, straight-grained, seasoned, out of wind, free from shakes, season checks, sap, pitch pockets or streaks, splits, rot, deadwood, unsound knots, loose knots, knots in clusters and large knots extending through the material. Small, loose or unsound knots may be bored out if the holes are thoroughly plugged with the same material as that of which the tank is made. Material having knots in the edges will not be accepted. No plugs will be permitted within 12 in. of the croze and no stave shall have more than one plug.

2. **Size.** The tank shall be 24 ft. in diameter (inside measurement) and 15 ft. 11 in. high. (The height of the tank to be the length of the finished stave.)

3. **Shape.** The tank shall be truly cylindrical, the diameter being the same from the top to the bottom.

4. **Bottom.** The bottom plank shall be 8 to 12 in. wide and 3 in. thick, jointed on two edges, with a 3 in. chamfer. All pieces shall be full length without splicing. The bottom shall be cut to the true circle of the tank and the planks marked and numbered to indicate their correct positions when the bottom is laid.

5. **Staves.** The staves shall be 6 to 8 in. wide, and 15 ft. 11 in. long, of uniform width throughout with finished thickness of 2¾ in. at the edges of the stave. The outer side of the stave shall be surfaced to the true circle of the tank and the edges accurately planed or sawed on radial lines from the center of the tank. The croze in each stave shall be 4 in. in the clear from the end of the stave, the croze being 2⅝ in. wide with a ⅝ in. gain, and shall be accurately cut to fit the true circle of the bottom.

6. **General.** (a) The tank shall be framed and jointed in such a manner that all joints may be made watertight without the use of any foreign material.

(b) The staves and bottom planks shall be fitted in a workmanlike manner before shipment, each piece being plainly marked to indicate its proper position in the tank.

(c) At least one additional stave shall be shipped with each tank to provide against possible shrinkage or damage.

(d) To facilitate erection the staves may be provided with dowels placed one-third of the length of the stave from the top, the dowels being ¾ in. in diameter and of the same material as the stave.

100,000 Gal. Tank

1. **Material.** The tank, consisting of staves and bottom plank, shall be made of cypress, redwood, white pine, or such other timber as may be specified by the engineer, and shall be sound, straight-grained, seasoned, out of wind, free from shakes, season checks, sap pitch pockets or streaks, splits, rot, deadwood, unsound knots, loose knots, knots in clusters and large knots extending through the material. Small, loose or unsound knots may be bored out if the holes are thoroughly plugged with the same material as that of which the tank is made. Material having knots in the edges will not be accepted. No plugs will be permitted within 12 in. of the croze and no stave shall have more than one plug.

2. **Size.** The tank shall be 30 ft. in diameter (inside measurement) and 19 ft. 11 in. high. (The height of tank shall be the length of the finished stave.)

3. **Shape.** The tank shall be truly cylindrical, the diameter being the same from the top to the bottom.

4. **Bottom.** The bottom plank shall be 8 to 12 in. wide and 3 in. thick, jointed on two edges with 3 in. chamfer. All plank 24 ft. or less in length shall be full length without splicing. Plank more than 24 ft. in length may be made in two pieces, joined together by means of an iron tongue with suitable slots sawed in the ends of the plank to receive the tongue which shall be ⅛ in. in thickness, 6 in. long and the full width of the stave. The bottom shall be cut to the true circle of the tank and the planks marked and numbered to indicate their correct positions when the bottom is laid.

5. **Staves.** The staves shall be 6 to 8 in. wide and 19 ft. 11 in. long, of uniform width throughout, with finished thickness of 3 in. at the edge of the stave. The outer sides of the staves shall be surfaced to the true circle of the tank and the edges accurately planed or sawed on radial lines from the center of the tank. The croze in each stave shall be 4 in. in the clear from the end of the stave, the croze to be 2⅝ in. wide, with a ⅝ in. gain and shall be accurately cut to fit the circle of the bottom.

6. **General.** (a) The tank shall be framed and jointed in such a manner that it may be made watertight without the use of any foreign material.

(b) The staves and bottom plank shall be fitted in a workmanlike manner before shipment, and each piece plainly marked to indicate its proper position in the tank.

(c) At least one additional stave shall be shipped with each tank to provide against possible shrinkage or damage.

(d) To facilitate erection the staves may be provided with dowels placed one-third of the length of the stave from the top; the dowels to be ¾ in. in diameter and of the same material as the stave. (See Pages 815 and 816.)

TAP, PIPE. A tool used to cut threads in metal pipe and to clean or recut worn or damaged threads.

Pipe Taps

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This tool consists essentially of a cylindrical sectioned, fluted steel cutting portion which terminates in a short shank and head for attachment to a brace. The fluted cutting end consists of four or more longitudinal shafts having lateral wedge-shaped teeth across their outer surfaces. Another type of pipe tap has a cutting portion in which the shafts consist of removable rectangular steel plates equipped with lateral wedge-shaped teeth on their outer surfaces. The steel plates are designed to fit in longitudinal grooves around the working portion of the tool and have an advantage over the ordinary pipe tap in that the plates can be removed and new ones inserted.

TOOL LIST. The following list of tools and personnel for a water service gang of eight men has been presented by the committee on water service to the A. R. E. A. as information, and is reprinted here as representing good practice:

PERSONNEL AND LIST OF TOOLS AND EQUIPMENT FOR WATER WORKS GANG

1 Foreman.
1 Pipe Fitter.
2 Tank Carpenters.
5 Water Works Men.

List of Tools for Water Works Gangs.

Name.	Amount.
Axes, Single Bit	2
Axes, Hand	2
Adzes	2
Blades, Hack Saw—12-in.	12
Blocks, Chain—one ton capacity	1
Blocks, Two pulley steel—Self lubricating for ¾-in. manilla rope	2
Blocks, Two pulley steel—Self lubricating for 1-in. manilla rope	2
Blocks, Steel snatch—Self lubricating for 1¼-in. manilla rope	2
Bars, Pinch	5
Bars, Claw	1
Brooms, House	2
Chisels, Track—With handles	4
Chisels, Cold—¾-in. x 7 in.	6
Chisels, Roundnose—¾ in. x 6 in.	6
Chisels, Diamond point—¾ in. x 6 in.	6
Coolers, Water—5 gal.	1
Cutters, Pipe—3 wheel No. 1	1
Cutters, Pipe—3 wheel No. 2	1
Cutters, Pipe—3 wheel No. 3	1
Cutters, Pipe—3 wheel No. 4	1
Cutters, Pipe—3 wheel No. 5	1
Derrick, sashen Pipe ⅜" cable	1
Drills, twist taper shank ¼ in.	2
Drills, twist taper shank $\frac{5}{16}$ in.	2
Drills, twist taper shank ⅜ in.	2
Drills, twist taper shank $\frac{7}{16}$ in.	1
Drills, twist taper shank ½ in.	1
Drills, twist taper shank $\frac{9}{16}$ in.	1
Drills, twist taper shank ⅝ in.	1
Drills, twist taper shank $\frac{11}{16}$ in.	1
Drills, twist taper shank ¾ in.	1
Drills, twist taper shank ⅞ in.	1
Drills, twist taper shank 1 in.	1
Drill Press, No. 1 for taper shank drills ¼ in. to 1 in., incl.	1
Die Plate, and bolt taps full mounted screw plate	1
Digger, Post hole	1
Dollies, Timber	2
Dies, Toledo Pipe No. 0	1
Dies, Timber Pipe No. 1	1
Dies, Toledo Pipe No. 4	1
Flags, Cloth—Red	4
Flags, Cloth—Green	4
Flags, Cloth—Yellow	4
Flags, Cloth—Blue	4
Fuses, Red	6
Fuses, Yellow	6
Files, 12 in. assorted ½ round	6
Files, 10 in. assorted ½ round	6
Files, 12 in. assorted flat	6
Files, 10 in. assorted flat	6
Hammers, Claw	2
Hammers, Machinist	3
Hammers, Calking	3
Hooks, Lug	2
Jacks, Track and handles	2
Jacks, Car Box 2x10-12 T	1
Kegs, Water	2
Lanterns, White	2
Lanterns, Red	2
Lanterns, Green	2
Oilers, Hand	2
Picks, Clay—With handles	12
Pots, Lead Pouring—No. 1 with 2 hooks each	2
Punch, Screw—With bar head and punch drills	1
Pump, Trench—With 12 ft. 3 in. suction hose and strainer	1
Pipe, Reamer and tap ¼ in.	1
Pipe, Reamer and tap ⅜ in.	1
Pipe, Reamer and tap ½ in.	1
Pipe, Reamer and tap ¾ in.	1
Pipe, Reamer and tap 1 in.	1
Pipe, Reamer and tap 1¼ in.	1
Pipe, Reamer and tap 1½ in.	1
Pipe, Reamer and tap 2 in.	1
Rope, Manilla ¾ in.	500 ft.
Rope, Manilla 1 in.	500 ft.
Ratchet, Improved Parker Boiler No. 2 for taper shank twist drills ¼ in. to 1 in.	1
Saws, Hand	2
Saws, Cross cut	2
Saws, Hack 12 in.	2
Shovels, Track No. 2	6
Shovels, Long handled roundnose	6
Spades, 16 in. square point title	6
Scythe, Brush	1
Sledge, 16 lb. with handle	1
Sledge, 12 lb. with handle	1
Sledge, 8 lb. with handle	1
Tool Grinder, without special attachments	1
Tool Box, Section	1
Torpedoes	12
Tools, Yarning No. 1	2
Tools, Yarning No. 2	2
Tools, Calking No. 1	2
Tools, Calking No. 2	4
Tools, Calking No. 3	4
Tools, Calking No. 4	4
Vise, Combination	1
Vise, Malleable pipe No. 1	1
Winches, Hand Power size "A" tapered drum	1
Wheelbarrows	3
Wrenches, Monkey 8 in.	2
Wrenches, Monkey 12 in	2
Wrenches, Monkey 18 in.	2
Wrenches, Stillson 8 in	2
Wrenches Stillson 10 in.	2
Wrenches, Stillson 14 in.	2
Wrenches, Stillson 18 in.	2
Wrenches, Stillson 24 in	2
Wrenches, Stillson 36 in.	2
Wrenches, Chain Ideal No. 2	2
Wrench, Chain Ideal No. 3	1
Wrench, Chain Ideal No. 4	1
Wrench, Chain Ideal No. 5	1
Wrench, Open end—double headed No. 34	1
Wrench, Open end—double headed No. 37	1
Wrench, Open end—double headed No. 38	1
Wrench, Open end—double headed No. 39	1
Wrench, Open end—double headed No. 41	1

TRACK TANK. A metal water trough located centrally between and below the tops of the running rails in the main track from which a locomotive traveling at high speed may take water through a forward-bent drop pipe or scoop attached beneath and connecting with the tender tank. It is commonly 6 in. to 7½ in. deep, 19 in. to 27 in. wide and

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1500 ft. to 2000 ft. in length, with vertically-inclined end sections as a protection against damage from lowered scoops. The average inside dimensions are 7 in. deep by 19 in. wide by 1800 ft. long. The depth

Typical Track Tank

is governed by the diameter of the scoop, which should be submerged at least two inches without scraping the bottom of the pan while operating; by the required tank capacity and by the allowable dap in the ties. The width must allow for side play in the spout as well as overflow due to disturbance, which amounts to 25 per cent to 50 per cent of the water supplied, as engines must maintain speeds of 20 miles per hour or more and frequently travel at 50 to 60 miles per hour while scooping water. The length of the pan depends on the locomotive tank requirements and on the distance between water stations. Track tanks are placed on level and preferably on straight track, though sometimes on curves as sharp as 2 deg., and are located between stations where full speed of trains is feasible and where drainage is readily obtained for the wasted water. They are made of 3/16 in. to 1/4 in. bent sheet steel shapes or of steel channel sides riveted on flat sheet steel bottoms, which may be removed economically for repairs. The 8 in. ties commonly used under track tanks are dapped as much as 2¼ in. and the tanks are fitted in these daps and secured to the ties by fastenings through angle irons riveted to the sides. The sections are made of convenient lengths for handling, usually 15 ft. and over. The end inclines are 5 ft. to 20 ft. long, the bottom incline plate being supported on a solid bed of wedge-shaped timbers.

Drainage from track pans is arranged sometimes by laying paving between double tracks with cross drains at subgrade to deliver the water into mains. An arrangement of surface box drains laid across the road bed between the ties at intervals of 50 ft. is also considered good track tank drainage practice.

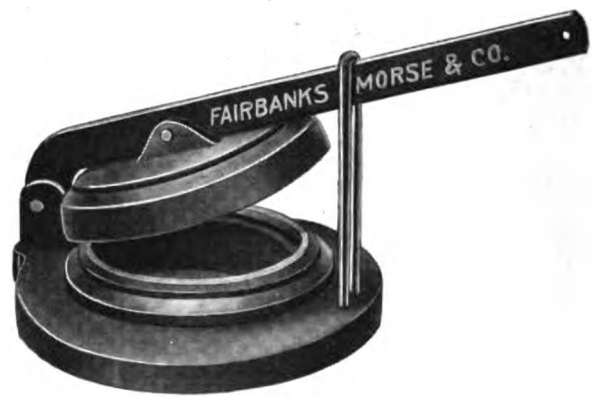
The water is usually tapped into the pan from two or more pipes of sizes and locations determined by the water pressure and the time required to fill the tank, the filling being preferably regulated by automatic valves. In freezing weather the water is heated by blowing steam into it through nozzles in the sides 20 ft. to 30 ft. apart; or by circulation from a pump with a heater or injector.

A locomotive will take from 1.5 to 3.0 gal. of water per linear foot of track pan under average conditions, depending on the size of the pan, the design of the scoop, its depth below the surface of the water and the speed of the locomotive while scooping. The advantage of a track tank is that trains do not stop while the locomotive is taking water. The use of the device is limited to locomotives provided with scoops, to locations between stations on level track where water supply and drainage conditions are favorable and to lines where numerous fast trains are operated.

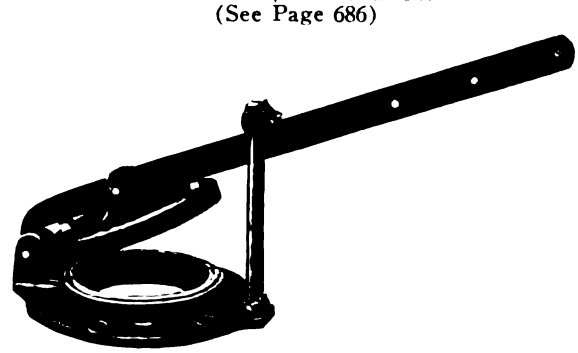
V

VALVE (Locomotive Water Supply). A lid, cover or plug which controls, by opening and closing, the flow of air, liquids, vapor or gas through a passage, pipe or other vessel.

A valve generally derives its name from its shape, use, motion or method of operation. The type commonly used for locomotive water supply are lift valves, float valves, check valves, and gate valves. Lift valves are the types in which the ball, cone or other stopper is lifted or raised clear of the valve-seat by the pressure of the water in the



Eclipse Water Tank Outlet Valve
Fairbanks, Morse & Co.
(See Page 686)



Halladay Water Tank Outlet Valve
The U. S. Wind Engine & Pump Co.

pipe, closing automatically when this pressure is released. This type is commonly placed at the upper end of the discharge pipes of water tanks and at

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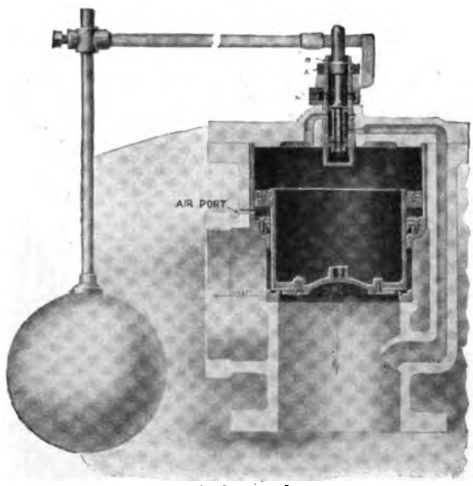
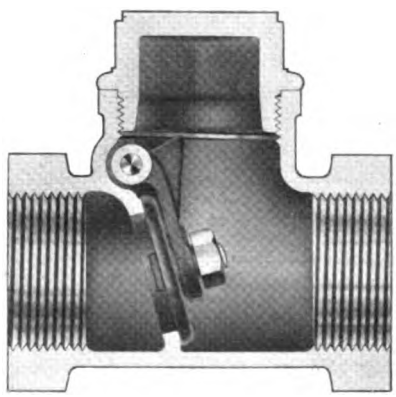


Float Valve
The Golden-Anderson Valve Specialty Co.
(See Page 696)

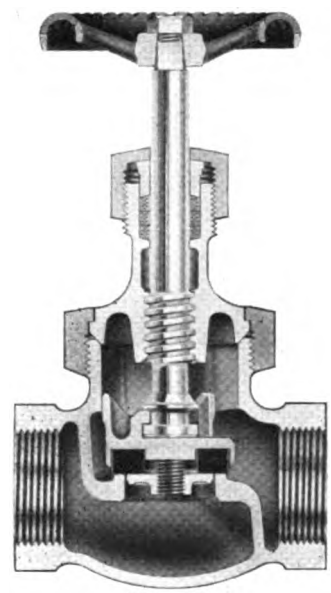
Swing Check Valve
The Kennedy Valve Manufacturing Co.

Crosby Improved Spring Seat Valve
The Crosby Steam Gage and Valve Co.
(See Page 678)

Crosby Spring Seat Valve
The Crosby Steam Gage & Valve Co.
(See Page 678)



Swing Check Valve
The Crane Co.
(See Page 674)



Globe Valve
The Crane Co.
(See Page 674)

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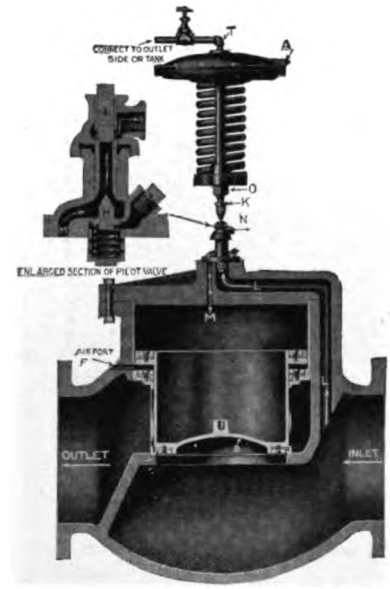
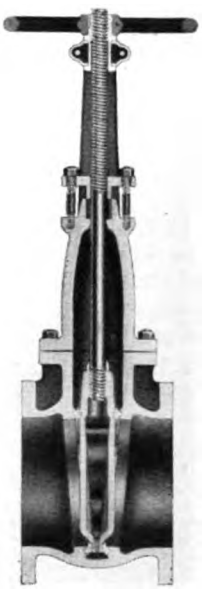
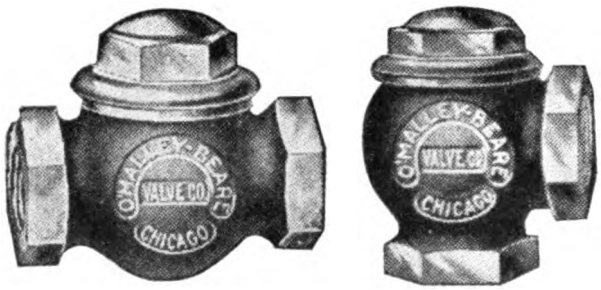
Swing Check Valve
Jenkins Brothers



Altitude Valve
The Golden-Anderson Valve Specialty Co.
(See Page 696)

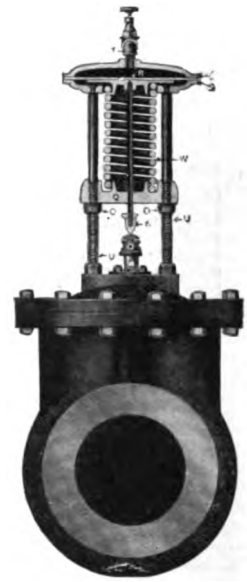


Gate Valve
The Crane Co.
(See Page 674)

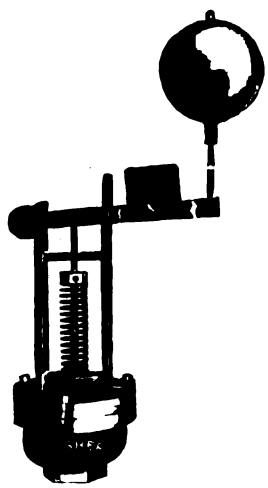


Horizontal Check Valve — Angle Check Valve
The O'Malley-Beare Valve Co.
(See Page 762)

Gate Valve
The Kennedy Valve Manufacturing Co.



Altitude Valve
The Golden-Anderson Valve Specialty Co.
(See Page 696)



Automatic Check and Float Tank Valve
The Fisher Governor Co.

the fluid ends of deep well pumps. The check valve is the type in which the stopper is usually a swinging lid or cover fastened on one side of the valve-seat or opening and operating from the pressure of the water against it. This type of valve is sometimes called a hinged valve and is largely used in the discharge pipe of centrifugal pumps, springs being sometimes employed to keep the valves closed, particularly at the fluid ends of pumps.

The float valve is similar in design to the lift valve except that the stopper is raised automatically from the valve-seat by means of a wire or chain passed over pulleys and connected to a float which rests on the surface of the water. This type of valve is commonly used in storage tanks or in connection

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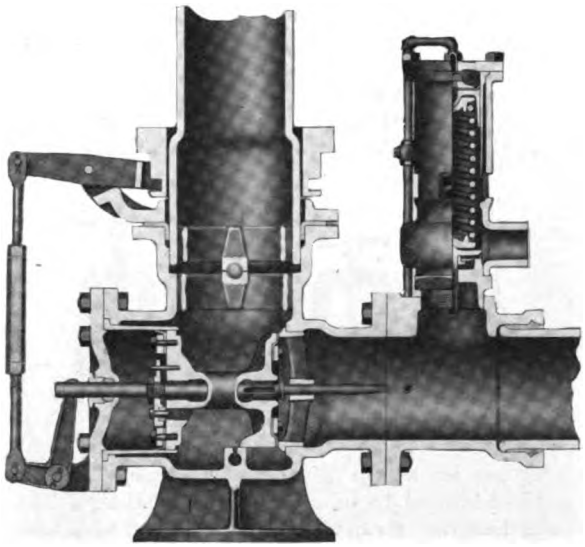
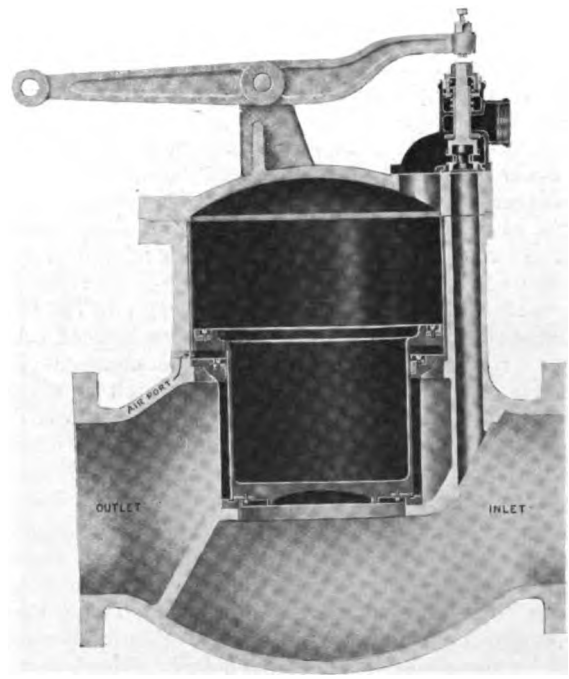
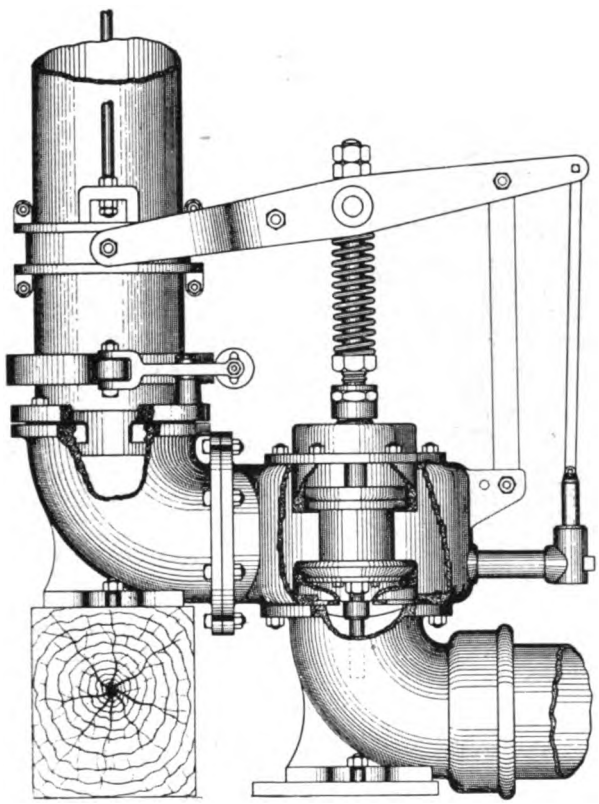


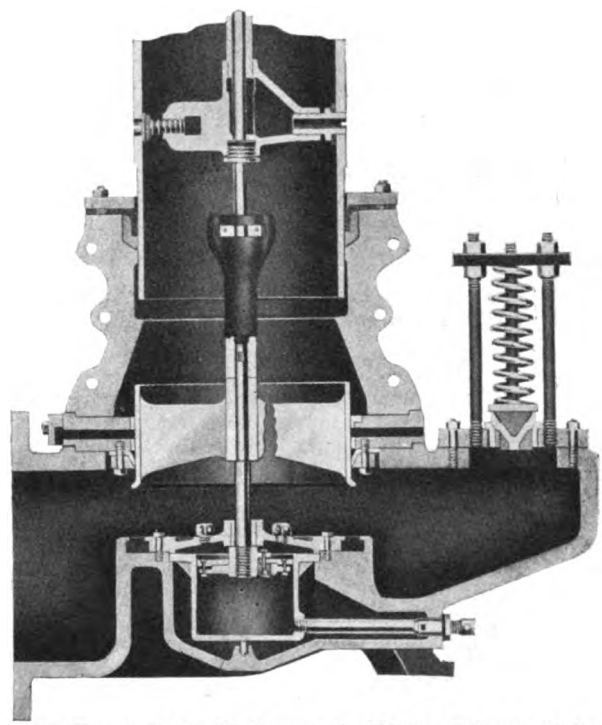
Main Valve and Automatic Relief Valve for Sheffield Water Column
Fairbanks, Morse & Co.
(See Page 686)



Golden-Anderson Water Column Valve
The Golden-Anderson Valve Specialty Co.
(See Page 696)



Balance Valve for Mansfield Water Column
The U. S. Wind Engine & Pump Co.



The Poage Style H Automatic Water Column Valve
The American Valve and Meter Co.

with electrically driven motors located in an open type of well or sump to control the flow of water automatically through the action of the float on the surface. Gate valves are used commonly as a means of isolating certain portions of a main while it is undergoing repairs.

While ordinary railway water supply valves operate automatically, there remains another type of valve associated with locomotive water columns in which the movement is purely a mechanical operation. Since locomotives must receive their water supply with as little delay as possible, the use of large diameter discharge pipes and valves naturally follows, and as these valves are under very heavy

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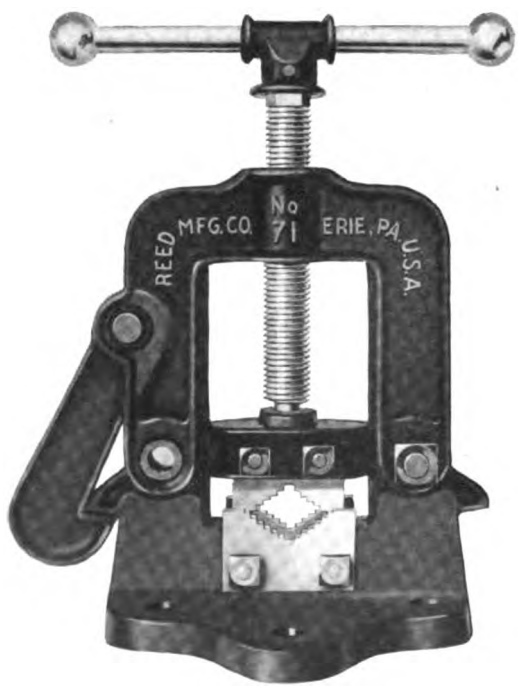
pressure, whether in a direct delivery storage tank or a water column, heavy vertical or horizontal types are necessary. The outlet valve of a direct delivery tank is usually placed on a frame from 6 to 12 in. above the bottom of the tank, or so as to be above the sediment. It consists usually of a swinging lid or cover fastened to the valve-seat on one side of the discharge pipe and is designed to be raised to an angle of about 45 deg. by means of an arrangement of pipes and chains conveniently located within easy reach of the operator. The valve closes by releasing the valve chain, the pressure of the water in the tank causing the lid or cover to fall down to its seat. Another arrangement of the same type consists of a disc fastened to a horizontal lever which is hinged to a lug at one side of the discharge pipe. It is operated by an arrangement of chains and pipes to raise the disc clear of the valve-seat, dropping back to its normal closed position automatically when released.

Water column valves are also either horizontal or vertical. The horizontal type consists of a double headed piston designed to slide in a horizontal plane within the main valve chamber to open and close the supply pipe. The pistons are mechanically operated by means of levers conveniently placed at the top of the water column for operation from the tender of a locomotive. The vertical type consists of a cylindrical main valve connected directly to the lower end of the operating rod and is operated vertically within the valve chamber by means of an arrangement of levers.

VISE, PIPE. A steam fitters' vise made especially to hold metal pipes. This device is essentially a bench tool, consisting of upper and lower oppositely serrated jaws, the upper jaw being movable while the lower jaw is stationary and integral with or fastened to a metal base plate. The upper jaw is fastened to the bottom of an upright threaded pressure screw turned with a cross handle and engaging the inside threads of a hole in the top of an inverted U-frame. One leg of the U-frame is hinged to the side of the base plate while the opposite leg is held in position by means of a metal toggle. The base plate is designed to be attached to a table, a bench or the like, by means of bolts, screws or a clasp. Some styles of vises have a lower V-shaped jaw fastened to the base plate, the upper jaw consisting of two movable metal lugs hinged to a cross-frame which is attached to the bottom of the pressure screw. This type of bench vise is especially useful for holding metal pipe fittings, as well as pipes. See Vise, Pipe.



Diamond Jaw Pipe Vise

Four Types of Pipe Vises

W

WATER COLUMN. An elevated spout connected to and depending from a vertical revolving discharge pipe, set close to a track to deliver water to locomotives.

The water column is set on the cover of a pit built to enclose the control valve, which is connected horizontally with the terminus of the water supply pipe line and vertically with the upright discharge pipe by an elbow which usually forms a part of the valve chamber. The vertical pipe is held upright by an encircling conical pedestal of iron two to four feet high, flared at the base and bolted to the cover of the valve pit. The cast iron or steel upright pipe terminates in a rigid or a flexible top elbow and spout; or it ends in a gooseneck or slow bend which fits loosely inside a telescopic spout. A modification is an upright pipe which terminates a few inches above the slow bend in order to extend the vertical column of water well beyond the delivery aperture.

The normal spout and valve movements are controlled by means of a system of levers, rods and counterweights. The revolving device, sometimes automatic and located between the control valve and the top of the base, returns the column to its normal position whereby the spout stands parallel to the running rails as soon as released from use. The pit and valve are so located that the upright pipe is not closer than the standard clearance distance from the center of track. The height of a revolving water column is governed by the height of the engine tenders rather than by the standard overhead clearance, since it does not extend over the track except when delivering water into a tank. On lines of more than two parallel tracks, the spouts of water columns serving locomotives on inside tracks are frequently supported by overhead bridges.

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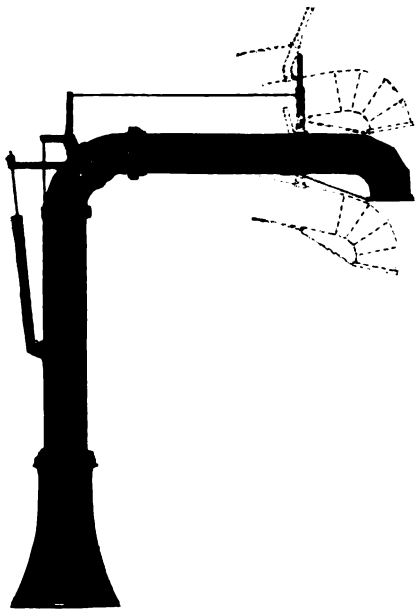
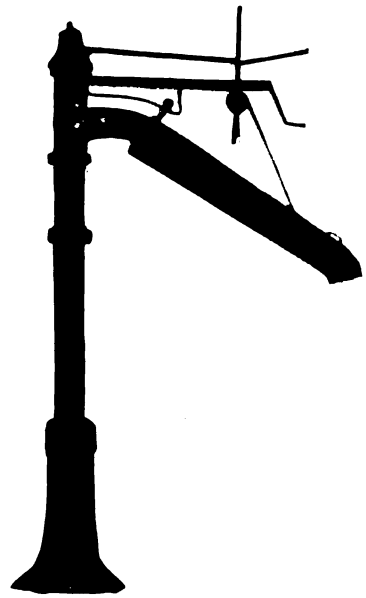
The water column is one of three modern products of more than 50 years of development in devices for delivering water to locomotive tenders, the others being the tank spout and the track pan. The early demands of railway operation did not exceed the service obtainable from hand or horse power pumps delivering water direct into locomotive tenders. The necessity for storage tanks gradually developed the wooden tank with the copper-riveted leather boot or elephant trunk as a water-delivering attachment, which was superseded by the fixed metal spout and tank valve. The fixed spout in turn was replaced by a flexible joint spout, which was improved later by the telescopic joint spout which is in use today on tanks serving the majority of water stations throughout the country. But water columns are used at many terminals and stations where traffic is heavy and locomotives must be watered at different points to prevent delays; where there is not room for tanks close to the tracks; on double track lines where one water column may be placed between tracks to serve engines on either side; and where the conditions or topography are such that the tank may be located most advantageously at a distance from the tracks.

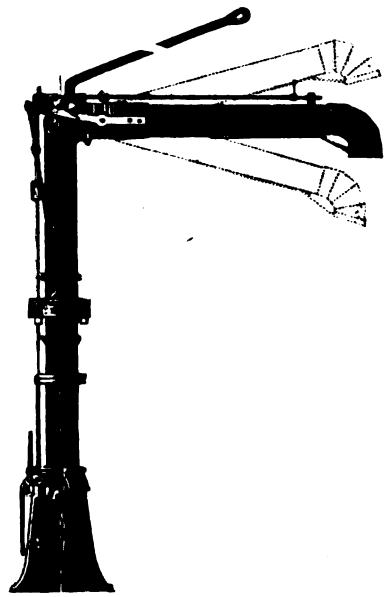
The tank spout saves operating time over former delivery devices chiefly through improvements in valves and handling fixtures. The water column further conserves operating time by multiplying the possibilities of the location of storage tanks and delivering apparatus. The revolving water column



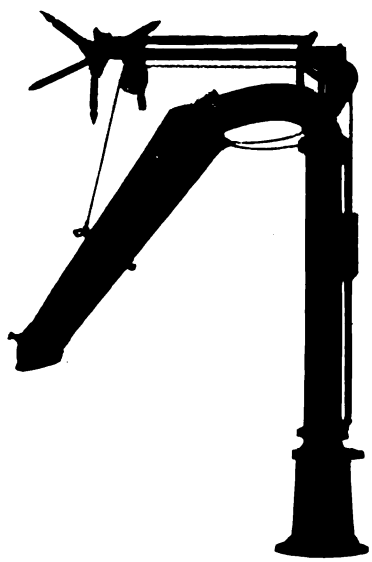
Golden-Anderson Flexible Water Column
The Golden-Anderson Valve Specialty Company
(See Page 696)



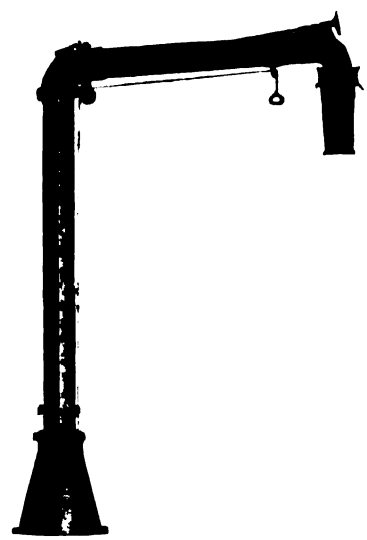
Poage Telescopic Water Column
The American Valve & Water Co.



Sheffield Flexible Water Column
Fairbanks, Morse & Co.
(See Page 686)



Telescopic Water Column
The U. S. Wind Engine & Pump Co.



Snow Rigid Water Column
The T. W. Snow Construction Co.

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may be set alongside a track anywhere within a radius of several hundred feet from the storage supply, being fed by means of a connecting line of water pipe; it occupies little space, is easy to operate and delivers water quickly and without water hammer if provided with proper valve control; it is safer than devices which overhang the track, because it can be arranged to open only by means of fixtures attached to the end of the elevated spout; it drains readily and effectually so as not to flood the track; it will not freeze easily and is not a fire hazard. Several water columns may be supplied from one water tank. A common arrangement is a T-branch pipe line parallel to the tracks with water columns at opposite ends so placed that engines of trains proceeding in either direction may take water conveniently while station stops are being made. A rigid water delivery device is easily broken when in use, by a limited movement of the locomotive, which must be spotted accurately to get the spout over the manhole in the tender tank. For this reason a rule issued on many lines is that a locomotive must be cut loose from its train before being spotted to take water.

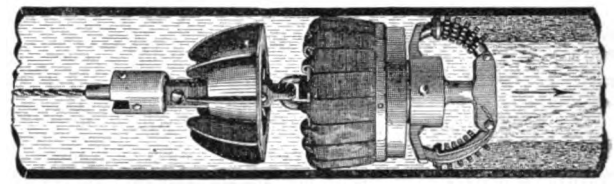
The development of locomotive water delivery has been along the lines of flexibility. The telescopic spout minimizes the inconveniences of spotting because of its range of operation. Increases in the capacities of tender tanks and in the demands for the reduction of delays have led to increasing the diameters of water columns from 6 and 8 in. to 10 and 12 in. and supply lines to 2 or more inches greater diameter to obtain maximum delivery. Valve improvements have reduced the head loss and water hammer.

The capacity of a water column and the speed of delivery to locomotives depend largely on the design of the supply line. The allowable velocity for a long supply line might be as low as 8 ft. per second, where as for a short pipe line the maximum of 12 or 15 ft. per second might be allowable. Tests made at the University of Illinois a few years ago indicate the maximum desirable flow through water columns to be 3,000 gal. per min. for an 8-in. water column, 4,000 gal. per min. for a 10-in. water column and 6,000 gal. per min. for a 12-in. water column. A 12-in. water column connected to a 14-in. supply line 1,000 ft. long should deliver 4,000 gal. per minute with approximately the same loss of head as a 10-in. water column connected to 1,000 ft. of 12-in. supply line discharging 2,750 gal. per minute, or an 8-in. water column on 1,000 ft. of 10-in. supply line discharging 1,750 gal. per minute. A reduction of head creates a demand for increased area of pipe lines and water columns. Allowance for an increase in the capacity of a pipe line should be made when two or more water columns are to be connected to one supply line if both columns are to be used frequently at the same time.

WATER CRANE. See Water Column.

WATER MAIN CLEANER. A device consisting essentially of a series of scrapers and piloting or propelling discs, flexibly connected, and of a design that will remove debris and incrustation from pipe lines while being forced through under water pressure or pulled through by cable.

Where water pressure is available, the operation



Water Main Cleaner
The National Water Main Cleaning Co.
(See Page 756)

of cleaning a pipe line consists of opening the main in two places, inserting the cleaner at one point, thereafter sealing the opening with a temporary section, and after inserting a temporary section with a riser pipe at the other point, of applying the water pressure, all material removed from the pipe being forced ahead of the cleaner and out of the riser pipe by the portion of water permitted to pass the cleaner.

WATER SUPPLY, LOCOMOTIVE. Water delivered from railway water stations to the tanks of locomotives to furnish steam for motive power. On steam railways water stations are generally located at intervals of 20 to 30 miles, these distances varying according to local conditions such as availability of sufficient supplies of good water, traffic density and the location of yards and terminals.

The usual sources of supply are streams, lakes, and wells. The water is made available for locomotive use by piping it to the railway tracks, where it is commonly stored in elevated tanks of from 50,000 gal. to 100,000 gal. capacity. It is frequently necessary to impound water behind dams in order to insure sufficient supplies at all times. Except in isolated cases where the topography of the country permits gravity delivery the supply must be pumped into a tank from which it is then delivered to the locomotive, or obtained through pipes from reservoirs into which it has previously been pumped. Gravity water supplies are highly desirable on account of the nominal cost of maintenance, even though they usually involve the construction of works at the intake, such as a dam as well as the purchase of right-of-way and the construction and maintenance of the pipe line.

Where pumping is necessary, the pumping station is located as near as possible to the source of supply, whether it be a stream, a lake or a well. Pumps are variously operated, the steam boiler being a common type at the smaller wayside stations where it is sometimes supplemented by a windmill. Pumps are also driven largely by internal combustion engines, a more recent development being the electrical plant which is rapidly coming into favor at large stations and terminals. The pump may be direct connected, as is common with the electric motor, or it may be belt-connected or geared to the steam or internal combustion engine.

Power pumping apparatus may be either of the horizontal or vertical type, designed to pump from drilled deep wells or from the more shallow dug or open type of wells, galleries, etc. The fluid end of the pump may be of the single-acting type of working barrel or it may have several pistons or plungers, which are operated from the ground surface by steam, belt or gear-driven machinery. Perhaps the

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commonest type of well pump is that in which the wooden working rod, or sucker rod as it is sometimes called, and one or more plungers or bucket pistons in the pump cylinder, are operated by a vertical power head. The pumping apparatus used for drawing water from streams, lakes, etc., usually consists of a screened intake four inches or more in diameter extended below the surface of the water, and a feed and discharge pipe three or more inches in diameter, connected to the engine which pumps the water into the supply tank alongside the railway track.

The pumping machinery is housed in a small building, preferably within a few feet of the source of the water supply, while the feed and discharge pipes, commonly cast iron, are placed in the ground below the frost line, the discharge pipe being commonly laid on a grade sufficient to drain the surplus water from it after cessation of pumping to prevent freezing usually, to a sump in the pump house, where it drains back into the water source through a suitable drip pipe.

Electric motors for pumping water to supply tanks use either direct or alternating current, the horsepower averaging from 5 to 50, depending on the conditions to be met, while the armature or driving part of the motor may be of the vertical or horizontal type. An advantage of electric motor pumping is that, with an automatic float valve, the actuation of the pump may be entirely mechanical. When water is drawn from a full tank the pump starts automatically and when the tank is filled the pump stops automatically, thus preventing overflow and the consequent waste of water, damage to the roadbed and danger to traffic without requiring the attendance of an operator. Where current is available, electric pumping is alike applicable to large and small locomotive water supply stations. From the storage tank water is delivered to the locomotive from a spout directly connected to the storage tank; or from a water column connected to a pipe line from the storage tank; erected at any convenient location close to the track; or from an open track pan located between the running rails and filled through a pipe line from the storage tank.

WATER TREATMENT. A process whereby water containing ingredients which are chemically or mechanically injurious to boilers is rendered harmless and fit to use in steam boilers.

No raw water is absolutely pure; that which falls as rain or snow absorbs gases from the air and animal, mineral or vegetable matter from the earth and rocks encountered after falling, flowing over, and seeping through the ground. The impurities in water may be in suspension as in the case of silt, which makes the water milky or muddy, but all water contains more or less matter actually dissolved so that it may appear perfectly clear even though it contains large quantities of solids in solution.

The waters of rivers, lakes, reservoirs and shallow wells may contain animal and vegetable matter in considerable quantities, but usually have relatively small amounts of mineral salts in solution, while waters from deep wells are usually free of animal or vegetable matter, but may contain large quantities of mineral salts. The gases most frequently found in water are oxygen, carbon dioxide and hydrogen sulphide. All of these impurities are undesirable ingredients that cause more or less trouble in boilers if present in quantity.

The suspended matter can usually be eliminated by giving it an opportunity to settle to the bottom of a tank or basin, or by passing it through a filter, but the dissolved matter can be removed only by pre-heating or distillation, which are generally impracticable; or by the use of chemicals. These operate by chemical actions that transform the dissolved solids into insolubles which are precipitated and appear in the water as suspended matter, which must then be allowed to settle. In some cases chemical action leaves solids of a different character dissolved in the water which may or may not cause trouble in the boiler.

While the presence of animal or vegetable matter may make a water decidedly objectionable for drinking purposes, it may be of little concern in a boiler. On the other hand, a water that is entirely suitable for drinking may contain mineral salts that cause serious difficulties in steam boilers. These dissolved solids may be divided into three classes from the nature of the troubles they cause; namely, scale producers or incrustants, corrosives and foam producers. Some solids are both scale producing and corrosive.

The following are among the more common materials that frequently cause trouble, although they are by no means the only ones.

Scale Forming	Corrosive	Foaming
Calcium carbonate (limestone)	Magnesium chloride	Sodium carbonate (soda ash)
Calcium sulphate (gypsum)	Sodium chloride (common salt)	Sodium sulphate (Glaubers salts)
Magnesium carbonate (magnesia)	Magnesium sulphate (Epsom salts)	Potassium carbonate
Magnesium sulphate (Epsom salts)	Oxygen	Potassium sulphate

Scale is formed as the result of heating water containing scale forming solids in solution. The

Graver Water Softener
The Graver Corporation
(See Page 698)

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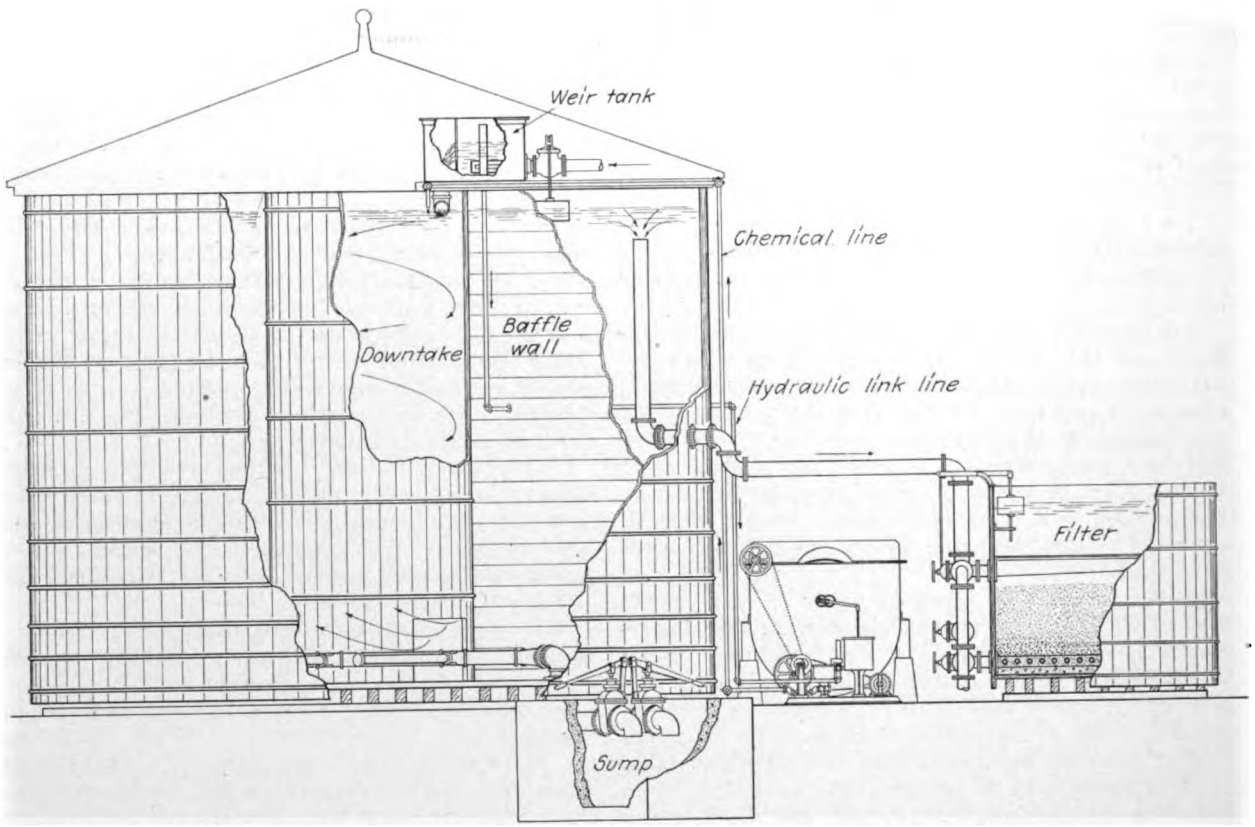
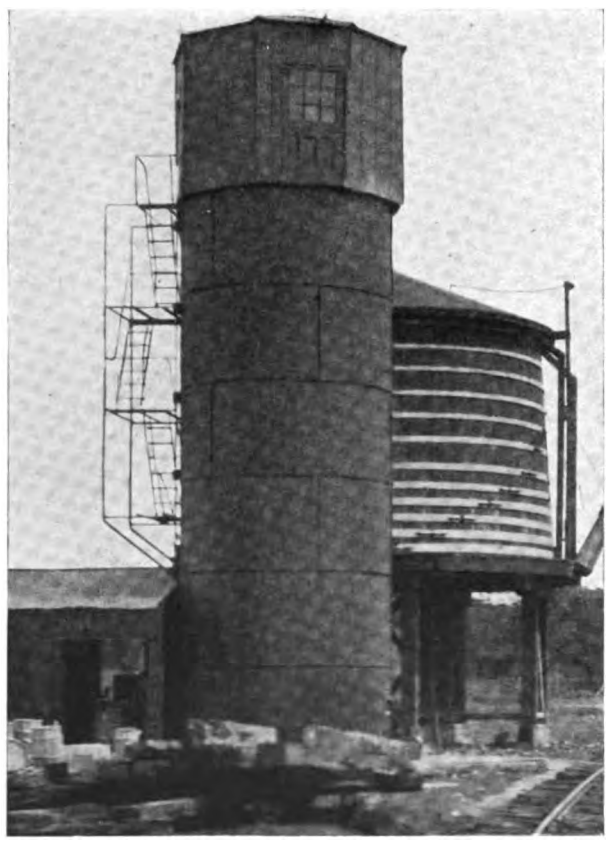


International Continuous Water Softening Plant
The International Filter Co.
(See Page 718)



American Water Softener
The American Water Softener Co.

carbonates of calcium and magnesium are thrown out of solution as soon as the water reaches the boiling point, but the sulphates do not precipitate until the boiler pressure has been raised sufficiently to give a temperature close to 300 deg. F. There is this further difference, that the carbonates, when present alone, will form only a relatively soft scale or sludge that is washed out of the boiler readily, while the sulphates form a hard, rock-like crust on the sheets and tubes that are removable only by chipping. Carbonate scale, when present in waters also containing sulphates, will be cemented in the sulphate scale.

The carbonate hardness may be removed from the water through chemical treatment by taking advantage of the fact that the calcium and magnesium carbonates are soluble only in water containing carbonic acid gas. If this carbonic acid is removed, the carbonates become insoluble and precipitate.

This may be accomplished by adding just enough lime (calcium hydrate) to take up the carbonic acid. This process, if completed perfectly, will remove all the carbonate solids and leave no dissolved solid in its place.

The sulphate hardness is removed usually by introducing carbonate of soda (soda ash, sal soda, wash soda). This combines with the sulphates of lime to form carbonates of lime and sulphate of soda. If enough lime is then added to neutralize any carbonic acid present, the carbonate of lime will be precipitated, leaving the sulphate of soda dissolved in the water. The sulphate of magnesia and

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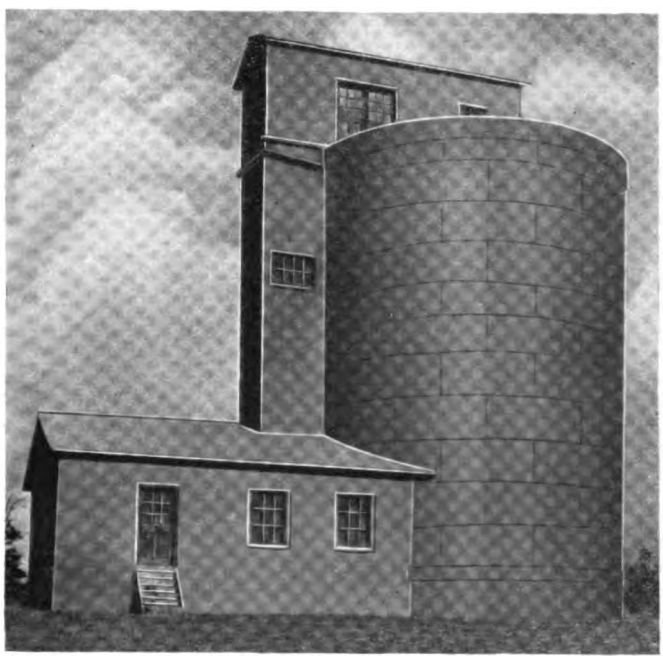
the nitrates and chlorides of lime and magnesia may be treated in a somewhat similar manner.

This brings out a further distinction between the carbonates on the one hand and the sulphates, nitrates and chlorides on the other. Treatment to remove the former leaves no residue dissolved in the water, while treatment for the latter leaves the sodium sulphate in the water, which may lead to difficulties, as explained later.

A considerable number of other chemicals may be used for water softening, but lime and soda ash are so much cheaper that it is only in exceptional cases or in proprietary boiler compounds that any of the others are used.

Corrosion is a complicated process concerning which there are many and various opinions. It takes place as rusting over considerable areas and in pitting that begins with very small spots. Since the introduction of superheater engines, the pitting of superheater tubes has occurred with waters that previously gave no trouble. No difficulty encountered in the use of water in boilers is more troublesome. The use of carbonate of soda (soda ash) or sodium hydrate (caustic soda) to render the water alkaline is one remedy applied.

Intermittent Water Softener
The T. W. Snow Construction Co.



Water Softener
The Refinite Co.
(See Page 788)

As a rule, water should be treated outside the boiler, but under certain circumstances it is entirely proper to use a boiler compound under the direction of a chemist skilled and experienced in water treatments. Unscientific use of boiler compounds will generally be of no benefit and may result in injury to a boiler.

Foaming results in filling the steam space of the boiler with bubbles which are carried over into the cylinders, a condition that may easily become so serious as to cause an engine failure. The exact reason for this condition is not well understood, although it is definitely known that waters containing concentrations of alkaline salts, that is, salts of sodium and potassium, will foam and also that the condition is aggravated by the presence of sediment or sludge in the water. This action of the sodium salts introduces a complication in water softening. Treatment for sulphate hardness is commonly done with soda ash, with the result that sodium sulphate is left dissolved in the water or in some cases an excess of the soda ash may also be present. Consequently, if the raw water contains a large amount of sulphate hardness with or without considerable quantities of the alkaline salts, the treated water may be so high in foaming solids that it cannot be used in the boiler. This accounts for the failures to treat some waters successfully. Because of the objectionable effect of treating with soda ash, the use of one of the barium salts is sometimes advocated, since its use leaves no dissolved matter in the water. The objections to barium salts are their higher costs and poisonous properties.

Foaming may be overcome or prevented by blowing off the boiler regularly to reduce the concentration of foaming solids, and by washing out frequently to get rid of the sediment. Anti-foaming compounds which are also used, usually contain tannin, vegetable oils, etc., furnished in the form of emulsions or pastes and applied in proper propor-

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tions. A compound is best used regularly as a preventative rather than as a cure for foaming, and for this purpose the solution is kept on hand to mix with each tank of water.

In order to treat water by any process efficiently, chemical analyses are necessary to show the quantity of each injurious ingredient. This information is used to determine whether, how and by means of what reagents the water is to be treated. A definite amount of chemicals in proper proportion must be mixed with a definite amount of water to obtain the results sought on the basis of the analyses, and these proportions must be constant unless varied in accordance with periodical analyses which should always be made at frequent intervals to detect changes in the water content which may frequently occur in any water, as in running streams after rains, or floods from melting snow. Thorough agitation of the water with the chemicals is necessary to obtain the desired chemical reaction in the treating plant, and concentrate the matter thrown out of solution in the form of a flocculent precipitate. A sufficient time must be allowed for the dissolved solids to be precipitated and to settle and leave the water in the purified state. It is usually desirable to supplement the process of sedimentation with filtering.

The two principal types of water softening plants in general railway use are, those in which reagents are introduced into the water and those in which the water passes through the reagent. Plants of the former type are of continuous and intermittent designs, this classification being based on the manner of their operation.

The intermittent apparatus consists essentially of a tank of the required size with an inlet pipe for raw water and a drain pipe and clean out valve at the bottom to carry away the sludge. Revolving agitators or air jets are used to stir the water during treatment, while small tanks for the chemicals are also provided. Usually a floating drain pipe is so placed as to remove the treated water from the surface of the reaction tank without disturbing the sludge nearer the bottom. In order to obtain an uninterrupted pure water supply by this method, two or more such tanks are commonly used and alternately operated.

In the continuous process, raw water is fed uninterruptedly into a tank while treated water is drawn off continually. These plants vary considerably in design, but are generally uniform in principle, there being two main portions, the reaction chamber and the settling and storage chamber, the water being fed into the first where the chemicals are introduced and a vigorous agitation is provided, passing thence down and out into the larger settling space where the water is quiet and the upflow from the bottom is slow, so that the precipitates separate gradually and fall to the bottom and the liquid becomes clearer as it rises. The chemical mixing apparatus may be a box with a weir and overflow, a system of siphons, a cone regulating device, or the like.

These water treatment processes all require the introduction of chemicals in definite proportions. In the second type of plants however, the water is treated by passing it through a filter containing a chemical reagent, known as zeolite. This consists of a compound of sodium, aluminum and silicon found as a natural mineral or made by a chemical process. When water containing carbonates and sulphates of calcium and magnesium is passed through the filter, the sodium in the zeolite is exchanged for the calcium and magnesium in the water salts so that the water passes out with carbonates and sulphates of soda instead. The sodium in the zeolite is renewed from time to time by injecting a solution of sodium chloride (common salt). This process is said to be capable of producing water of zero hardness.

The most important effects of scale on the heating surface of a boiler are:

(1) Reduced conductivity leading to waste of fuel in evaporation, (2) danger of burning the metal through overheating with the possibility of a blister on a firebox sheet or a ruptured flue, and (3) decreased life of the boiler and flues. A flue covered with scale expands more than a clean flue and therefore much more than the body of the boiler, with the result that the connections at the ends of the boiler are loosening continually. In consequence a large amount of boiler repair work is required to calk leaks and the interval between flue renewals is greatly lessened. The losses are, therefore, waste of fuel, heavier boiler repairs, more frequent renewals, engine failures and reduced power of the locomotives.

As most substances dissolve more readily in hot than in cold water, while some salts are precipitated readily by heat, preheating is recognized as an advantage in water treating plants provided it can be done without undue expense, but it is not usually practicable for locomotive supplies. On account of the considerable space required for a plant in which the treated water may be allowed sufficient time to clarify completely and because of the expense of extensive water treating installations or failure to foresee future demands, there has been a tendency to build treating plants so small that they become inadequate when traffic is heaviest and the requirements most exacting. This condition results in crowding the process and obtaining partly treated, cloudy water which gives trouble in the boilers. As the exact requirements at individual treating plants are rarely duplicated, the best results are usually obtainable only after complete and careful expert surveys based on analyses of the water, examination of the source of supply, consideration of its permanency, and of the probable future requirements for the locomotives.

Given an adequate treating plant, its efficiency depends largely on the intelligence and care with which the maintainer carries out the instructions of the chemist in charge of water treatment.

WELL, ARTESIAN. A deep bored well in which the water rises to or above the surface of the ground, on account of hydrostatic pressure on the underground reservoir from the superelevation of the source of supply. Commonly any bored well 100 ft. or more in depth whether flowing or pumped is erroneously called artesian.

WELL DRILL. A machine used for sinking in the earth to obtain a water supply.

Well drills are usually heavy machines of the jumper or diamond drill class. Some of the lighter machines, made to drill wells less than 500 ft. deep,

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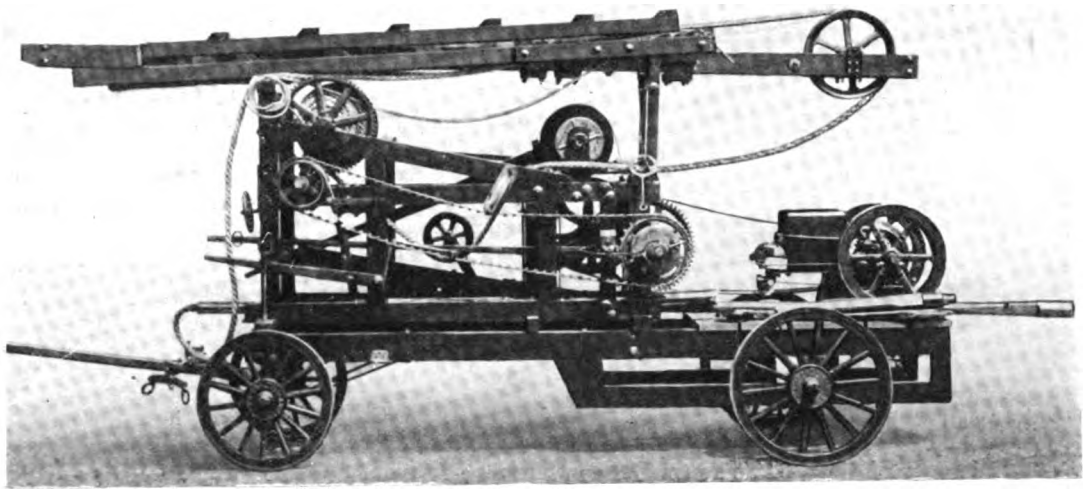
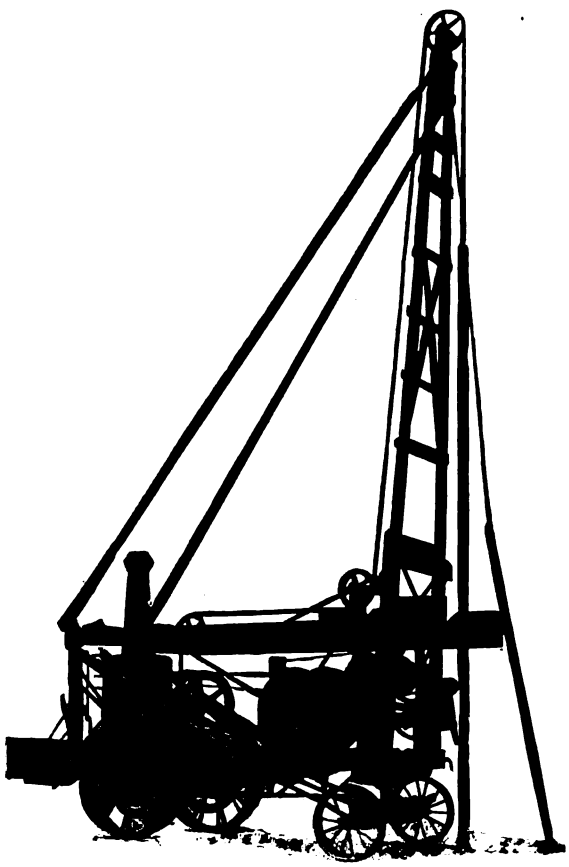


Power Well Drilling Machine
Williams Brothers



Traction Keystone Drill
The Keystone Driller Co.

are portable in that the outfit is mountable on a special four-wheeled wagon. When erected on the rectangular drill frame, the mast stands vertically at the front, supporting from a top pulley a cable to which is attached a sinker bar, to the lower end of which drill-bits commonly of 2-in. to 4-in. diameter may be screwed. The cable passing over the pulley descends to a horizontal winding drum which is rotated by power, being usually belt-driven from the fly-wheel of a steam or gasoline engine and controlled by a friction hand brake. As the drill hole is deepened, additional pipe is connected to the casing and additional sinker rods are screwed to the bit.

Jumper drills are similarly operated from the ends of walking beams while diamond drills and shot drills are rotated, the working ends of the rotary types being pipe connections with hollow circular diamond or hard steel studded cuttings ends called crowns, for grinding the rock and cutting out cylindrical cores. Small diamond drills are frequently used in explorations of the strata on which it is proposed to locate the foundations of bridges.

WELL HEAD (Locomotive Water Supply). A power machine (located over the top of the casing of a well) consisting essentially of a crank shaft and pinion shaft operated by a power unit, by which the piston rods of a pump are raised and lowered to lift water from the well.

WELL INTAKE. A sump sunk in the ground at the source of water supply, usually on open-top box of masonry with screened inlet pipe, and one or more outlet pipes placed above the central settlement basin.

Sometimes the intake well has two or more sediment chambers, the water entering the first chamber through the intake line from the source of supply and passing into the second chamber through pipes having fine mesh screens over their ends, the first and largest chamber thus retaining the heaviest particles, while the second and third chambers receive the finer particles of silt before the water passes on through the suction pipe and pump to the storage tank. Wells of this type have timber or cast iron frames and covers in the tops which can be removed when the sump is being cleaned.

WIND MILL. A machine consisting of an elevated wood or steel wheel which is revolved by the action of the wind, to operate the gears that raise and lower a pump rod. This device is commonly

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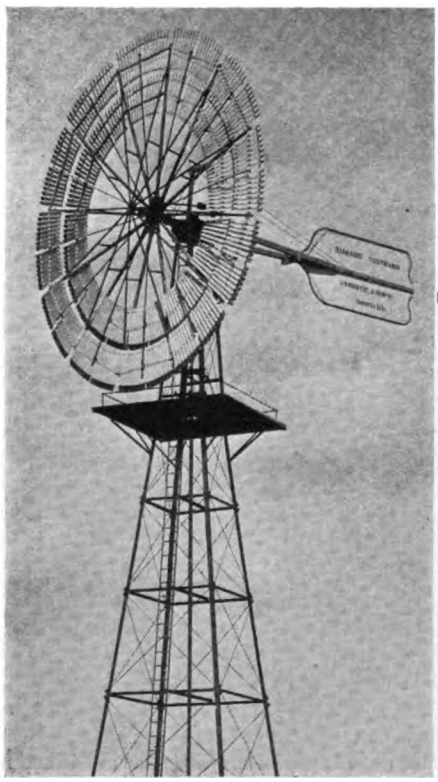
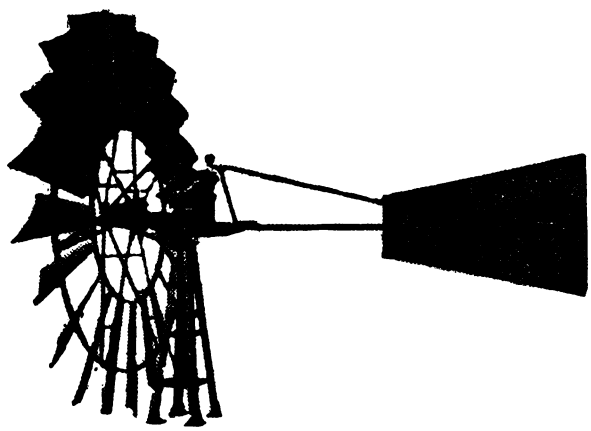
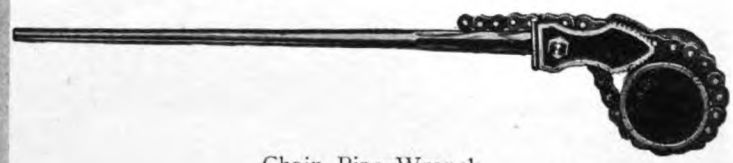


A Common Form of Windmill



Steel Windmill

used in railways as an auxiliary pumping apparatus for deep well locomotive water supplies. It consists essentially of a series of one or more short, flat, wooden cleats or sometimes of concave steel propellers radiating from the axle to form a wheel from 14 to 30 ft. in diameter, mounted on a wood or steel tower. The movable cleats of a wooden wheel are designed to open at an angle of about 45 deg. when the wheel faces the wind in which position it is kept by means of a thin, rectangular wood or steel weather vane hinged in a vertical plane at the rear and of the horizontal pivoted shaft which carries the wheel at its opposite end. When the mill is not in use the vane is folded against the wheel, causing the propellers to close and the wheel to swing edgewise instead of facing the direction of the wind, or the propellers are designed to assume a horizontal position when not in use, either arrangement tending to permit the wheel to withstand the force of the wind without danger of breaking the apparatus or causing it to operate. The operating gears are commonly arranged for shifting to steam or other power provided, when the wind fails. While this type of pump is not as reliable as others owing to the uncertainty of the wind, it forms an economical auxiliary, especially at wayside stations in flat open country.

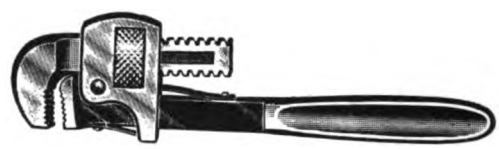


Chain Pipe Wrench

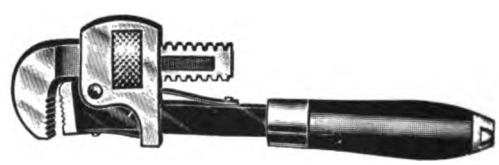
Reversible Chain Pipe Wrench

WRENCH, CHAIN PIPE. A pipe fitters tool designed essentially to turn metal pipe or pipe fittings which cannot be handled effectively with an ordinary wrench. A chain pipe consists of a bar similar to a pinch bar but with a working end terminating between a pair of pivoted V-shaped jaws equipped with lateral wedge-shaped teeth on their top and bottom surfaces with a chain to enlace the pipe. The chain is wrapped around the pipe to hold the bar in position, while the teeth of the V-shaped jaws grip into the pipe and afford a powerful leverage.

WRENCH, STILLSON PIPE. A pipe fitters tool signed essentially to turn metal pipe or pipe fittings of wrench is similar to a monkey wrench except



Stillson Pipe Wrench with Steel Handle



Stillson Pipe Wrench with Wood Handle

that the jaws are equipped with lateral wedge shaped teeth to afford a firm grip on the pipe. Unlike the monkey wrench the movable hook bar jaw of the Stillson wrench is at the end and is operated by means of a circular thumb screw in a collar fastened to the end of the tool near the fixed jaw. The thumb screw is equipped with inside threads which mesh with the teeth on the shank of the movable jaw and as it is turned the jaw is extended or returned as desired.

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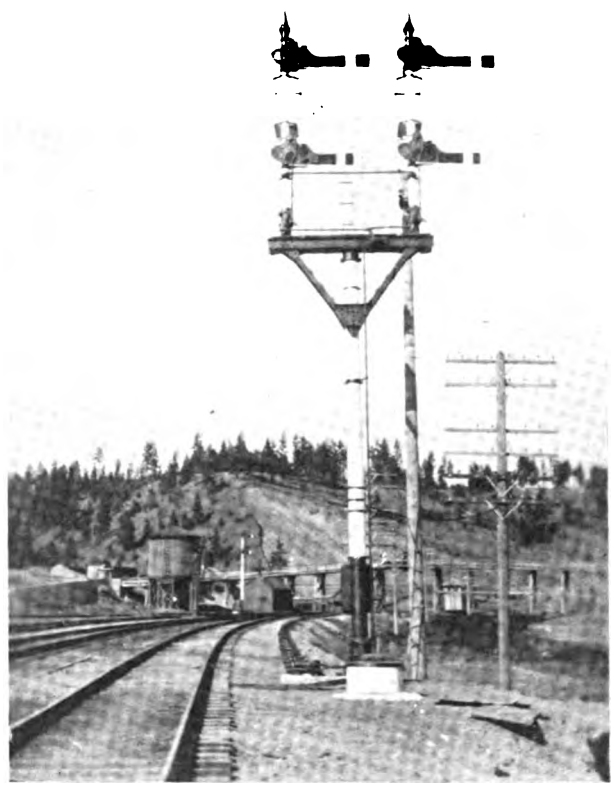
The Signal Section



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A

A. C. The abbreviation used for alternating current.

A. C. FLOATING STORAGE BATTERY SYSTEM. A power supply for the operation of signal devices by means of which alternating current is transformed into direct current by rectifying devices located at the points of load.

This system consists of a mechanical or chemical rectifier to which a source of alternating current is applied which is transformed into direct current for keeping charged a set of storage batteries located at a signal or other location. The storage batteries are connected in multiple across one side of the rectifier so that they are in a floating relation to each other, the storage batteries receiving a trickling charge of about one-half ampere direct current. The voltage of the rectifiers is sufficiently high so that they always supply current to the batteries, keeping them in a fully charged condition and ready for any emergency at all times. In signal service, a rectifier should be able to deliver direct current to the battery ranging from 0.1 ampere up to one ampere which is the range of demand for direct current automatic signal apparatus. In general, a rectifier should not be used to charge more than seven storage cells in series. The size of each battery is determined by its load and the number of days it is desired that the battery should carry the load with power off of the line.

This system may be used in connection with automatic block signals, automatic highway crossing protection, interlocking plants, etc. See Rectifier.

AIR GAP. Any break in a circuit wholly occupied by air. It commonly refers to the space between the ends of the poles of an electro-magnet and its armature.

The direct current signal relay is an example of the type of apparatus using an air gap. The R. S. A. specifications require that a minimum actual air gap between the armature and the cores be maintained by the use of a non-adjustable hard bronze stop pin so placed that its position relative to the armature shall be fixed so that when the armature is picked up it will strike against the stop pin near the edge opposite the bearings and midway between the magnet cores. The air gap between the pole-face and the armature for a relay with two fingers must not be less than 0.020 in. and for a relay having three or more fingers not less than 0.015 in.

The importance of a properly maintained air gap in relays and similar signal apparatus cannot be overestimated because a reduction in the air gap below that designed for the particular apparatus may result in a false clear signal failure. For this reason no unauthorized person should be allowed to make any adjustments on instruments which will produce this result.

ALTERNATING CURRENT. A current of electricity which flows alternately in opposite directions, its magnitude varying from a maximum in one direction through zero to a maximum in the opposite direction and back again according to the laws of simple harmonic motion.

A cycle is a complete change from any value to the corresponding value in the opposite direction and back again. The number of the cycles occurring per second is called the frequency and there are two alternations in each cycle. The number of alternations is generally spoken of per minute and the

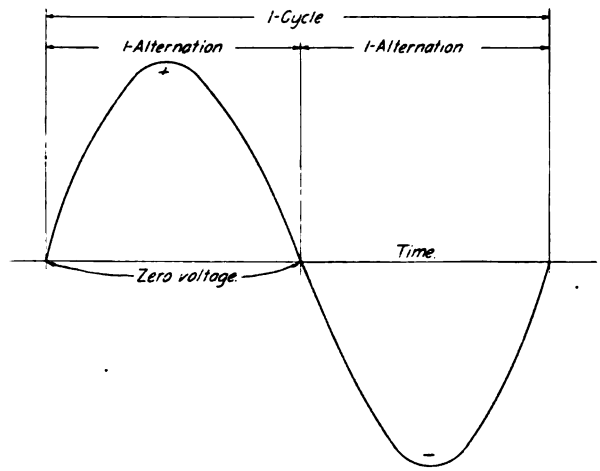

Illustration of Terms Used with A. C. Waves

frequency may therefore be given in cycles per second or alternations per minute.

Alternating current is used extensively for light signals, motor-driven semaphore signals and track circuits in connection with a system of a. c. signaling or in localities where direct current track circuits cannot be used safely because of the prevalence of foreign current. It is necessary to use a. c. signaling on roads using electricity for propulsion purposes, where the rails are used for the return circuit in the propulsion system. See Track Circuit.

ALTERNATOR (Or Alternating Current Generator). An electro-mechanical machine for transforming mechanical energy into electric energy, used as a means of furnishing electric current for signaling or other purpose. The current flows in a given direction in the conductors at one instant and in the opposite direction in the same conductors the next instant, hence the name alternator.

This type of machine consists of two main parts, a revolving member and a stationary member. The revolving member has insulated metal rings mounted on one end of its shaft to which are connected the ends of various coils. Metal brushes, which are in turn connected to the external circuit, rest on these rings which may vary from two to six in number. Each member is provided with insulated conductors. One member forms the electro-magnetic field and the other member the armature. The electro-magnetic field is often built up by an outside source of direct current, usually by a small d. c. generator.

In the smaller machines the electro-magnetic field is formed by a frame (the stationary member) which is part of the magnetic circuit to which the electro-magnets or poles are attached and the revolving member is the armature containing many coils of wire. The rotation of the armature causes the

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armature coils to cut the lines of force produced by the electro-magnetic field, thus generating an electro-motive force. In the larger types of machines the armature is the stationary member and the electro-magnets or poles are mounted on the revolving member. This revolving field type has the field coils excited by direct current led into the coils through slip rings usually mounted on the alternator shaft. In either case the lines of force are cut, generating an e. m. f. When a machine has a revolving field this field is called a rotor. The arrangement of the coils in a machine determines whether single phase, two phase or three phase alternating current is generated by the alternator.

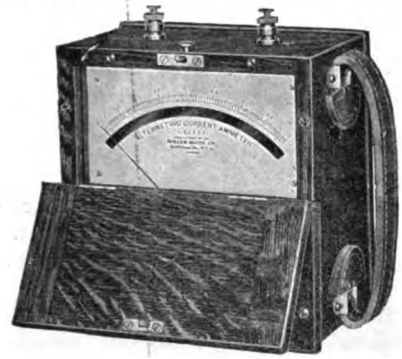
Alternators of various capacities are used in central power stations for the generation of current for alternating current signal transmission systems. One road uses a 100 kv. a. 60 cycle, 4400 volt generator; another uses a 75 kv. a. three phase 60 cycle generator with a 7.5 k.w. 125 volt d. c. generator direct connected for the exciter while a third uses a 75 kv. a. single phase, 25 cycle, 440 generator with a 10 k. w. 220 volt d. c. generator for the exciter, all being steam driven. These sizes are typical of those used in main power houses for signal purposes. Gasoline electric generating sets of smaller output for different branches of signal service come in 1, 3, 5, 10 and 25 kv-a. sizes for both direct and alternating current circuits, one, two or three phase, 25 or 60 cycles and in standard voltages.

Among other things, the R. S. A. specification for alternators require that all bearings be readily replaceable and provided with babbit or bronze linings, plain bearings shall be self-oiling with ample surface for cool running and means for preventing oil working into the rotating element, upper bearings to be removable without removal or displacement of shaft on sizes of 50 kv-a. and over; rotor must be mechanically strong and able to run at 25 per cent over speed with safety and fans or projecting parts must be suitably screened to prevent injury; while the finished rotor shall be properly balanced and shall run smoothly without injury or vibration under all conditions of operation. The collector rings shall be so mounted that air can circulate freely around them and the construction shall be such that they may be removed easily for cleaning. Each brush shall be separately removable and adjustable without interfering with the others; insulating washers and bushings shall be damp proof and unaffected by temperatures up to 100 deg. C.

AMMETER. An instrument for measuring the current flowing in a signal or other electrical circuit in terms of amperes. It is used principally in testing the amount of current flowing through track circuits, track or line relay coils, signal slots, indicators and similar signal apparatus and in signal circuits where it is important to know that the circuits or instruments are receiving the amount of current from batteries or other source of power supply required for their proper operation.

Ammeters are constructed in a number of different styles and types, the five most common classes being the moving coil, the electro-magnetic, the induction, the electro-dynamometer and the hot wire types.

The type most extensively used for d. c. signal purposes is the D'Arsonval galvanometer or moving coil type, which consists of a light coil of copper wire mounted on a pivoted frame to which is attached a pointer moving over a fixed scale and a soft iron magnetic core. This wire carries the entire current to be measured, or a part of it when a shunt is required. The coil is located between the pole pieces of permanent magnets, by which a magnetic field is maintained and the coil of wire on its pivoted frame rotates in the space between the core and the pole pieces. Its operation depends upon the fact that when current flows through the coil it tends to rotate and assumes a position at right angles to the lines of force set up by the permanent magnet. One of the chief advantages of this instrument is that the earth's magnetism and other external fields, if not too powerful, have little effect on it. This type of instrument is for direct current use only. Where heavy currents are to be measured, shunts are used to allow only a little current to flow through the coil and the scale is calibrated accordingly.



Inspector's Type, Alternating Current Ammeter
The Roller-Smith Co.

Direct Current Ammeter
The Weston Electrical Instrument Co.

Inspection Volt-Ammeter
The Railroad Supply Co.

The electro-magnetic type is based upon the law that like poles of magnets repel, and unlike attract, soft iron rods becoming magnetized when current passes through the coil used with them. The electro-magnetic type of instrument can be used for measuring either alternating or direct current.

The induction type consists of a fixed coil of wire, carrying the current to be measured and a movable disc such as aluminum. The magnetic field set up

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by the fixed coil reacts upon the induced currents in the disc, causing a deflection. This type of

Triple Range Ammeter
The Weston Electrical Instrument Co.

ammeter is used for the commercial measurement of alternating current.

The electro-dynamometer type consists of a stationary and a movable coil. The action of the magnetic field of the stationary coil on the current in the moving coil tends to rotate the moving coil. This instrument may be used for alternating or direct current work.

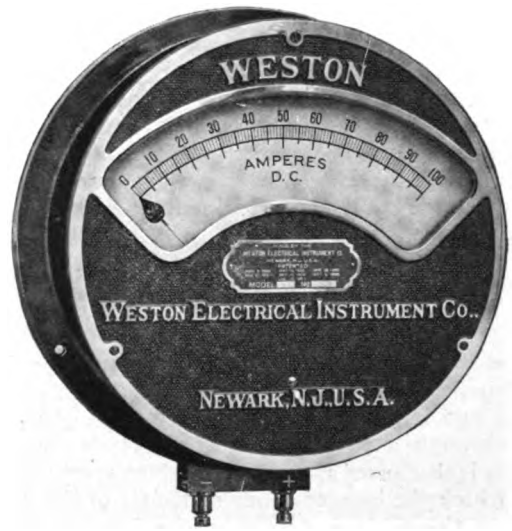
Miniature d'Arsonval Dead-beat Type Portable Volt-Ammeter
L. M. Pignolet

The hot-wire type is entirely different from the others. The principle of its operation is based on the heating effect produced by a current passing through a wire having certain properties, as the heat produced is proportionate to the square of the current value. As the temperature rises the wire expands and this instrument utilizes the linear expansion for reading the current flowing in a circuit. It is used in connection with a shunt, is free from inductive effects and magnetic disturbances, may be used in either alternating or direct current circuits, and is independent of the frequency and wave form of alternating current.

Direct Current Volt-Ammeter
The Roller-Smith Co.

Ammeters are instruments of low internal resistance and so arranged that considerable current is required to give readable deflections on the scales. This is necessary because they are placed in series in the circuit and high resistances inserted would change the amount of current flowing through the circuit, preventing a true value being obtained.

The ammeter used by signal supervisors, inspectors and others for testing purposes, is a portable instrument approximately 1½ in. by 4½ in. by 4⅝ in., while that furnished signal maintainers is usually a smaller, less accurate but more rugged instrument of pocket size. This instrument generally is a volt-ammeter having a scale to read pressure (volts)



Round Pattern Direct Current Power-board Ammeter
The Weston Electrical Instrument Co.

and another to indicate the value (current), the tests desired being made by connecting the wire leads to the proper terminals of the instrument. See Voltmeter.

AMPERE. The practical unit of measurement of electric current or the rate of flow. An ampere is that unit of current which will be caused to flow by an electromotive force of one volt through a circuit having one ohm resistance.

When an electromotive force overcomes a resistance, a current of electricity flows. Unlike the electromotive force and the resistance, current flows only through a closed circuit. The analogy of water flowing through a pipe may be used to illustrate the units. That which causes water to flow in a pipe is the pressure or head; that which resists the flow is the friction of the water against the pipe, and the rate of flow may be represented by so many cubic inches of water per second. The water pressure or head corresponds to the electromotive force or volts; the friction to the resistance in a circuit, and the quantity in cubic inches per second to the rate of current flow or amperes. The flow increases with an increase of pressure but decreases with an increase of resistance. The relation between amperes, volts and ohms is represented by Ohms Law, $I = \frac{E}{R}$ in which I is the current in amperes, R the resistance in ohms and E the electromotive force in volts. The standard of measurement for an ampere is a current which will deposit 4.024 grammes of silver in one hour on one of the plates of a silver volt-ammeter from a solution of silver nitrate containing from 15 to 30 per cent of the salt having a specific gravity of 1.15 to 1.33.

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AMPERE HOUR. A unit used to represent the quantity of electricity conveyed by one ampere flowing for one hour, which is the equivalent of 3,600 coulombs. If the quantity of electricity flowing is one coulomb per second the amount is one ampere. By the use of the term ampere it is unnecessary to specify the flow as a certain quantity per second. Primary and secondary cells used in signal and other railway department work are rated in ampere hour capacity, as for example: 40, 80, 120, 300, 500 ampere-hour capacity, a 500 ampere-hour cell being designed to give a rated output of one ampere continuously for 500 hours, 2 amperes for 250 hours, 5 amperes for 100 hours, etc. In testing cells for ampere-hour capacity, the tests are conducted at a temperature rating of not less than 70 deg. F. See Coulomb.

AMPERE TURN. A unit of magneto-motive force equal to that produced by one ampere flowing around a single turn of wire.

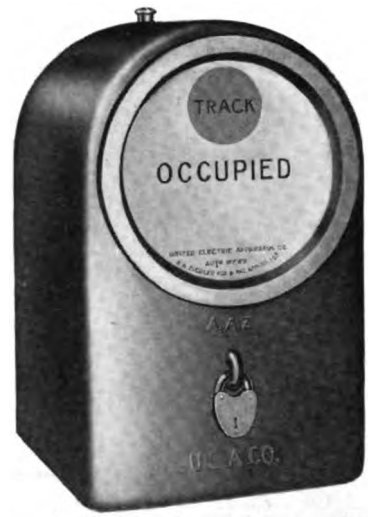
In a magnetic circuit, the magneto-motive force is similar to the electromotive force in an electric circuit and in a similar manner the flow of magnetism through a magnetic circuit depends upon the force which causes it to flow, and upon the resistance which the iron or other materials of the circuit offer to the passage of the magnetism or lines of force. The resistance offered by a magnetic circuit to the passage of lines of force is known as reluctance, while the lines of force are known as magnetic flux, or simply flux. A current of four amperes flowing through a turn of wire will produce four times as many lines of force as are produced by one ampere, while a current of one ampere flowing through four loops of wire will set up the same magnetic field as would be produced by a current of four amperes flowing through one turn. In every case the strength of the magnetic field is proportional to the product of the amperes of current and the number of turns through which they flow, the size of the wire having no bearing upon the magnetizing force. The ampere turn is used extensively in calculations and designs of electro-magnetic apparatus. See Lines of Force. Also Reluctance. Also Permeability.

ANNUNCIATOR. A device designed to give advance indications of the approach of trains.

It is used at interlocking plants to indicate to the leverman the approach of a train at some point far enough outside the limits of the interlocking (varying from ½ mile to 2 miles or more) to allow him to line the route up properly in advance of the trains' arrival. Annunciators are used most frequently at plants where there are obstructions to the towerman's view and where frequent train movements take place. Annunciators are also used at passenger stations, crossing watchmen's shanties, switchmen's shanties and other places of a similar character where the view of the tracks may be obstructed or weather conditions make such a device necessary.

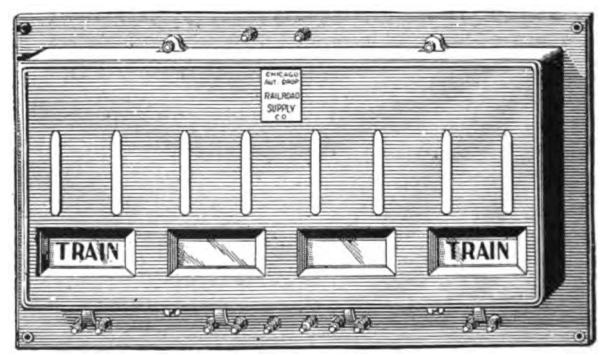
Such devices are designed to give either an audible or a visible warning or both. They are usually operated by the track circuit through contacts of the track relay in automatic signal territory. Outside of such territory they may be operated through a contact made by a track instrument actuated by the passage of a train or by means of a short track circuit section of two or three rail lengths in which one rail only is insulated, the train on bridging the rails actuating the circuit.

Visible annunciators are either of the drop type or of the same general form and appearance as indicators, while the audible type in general is a



D. C. or A. C. Disc Annunciator or Indicator
The United Electrical Apparatus Co.
(See Page 823)

bell or buzzer. The R. S. A. specifications for an annunciator bell require that it be either a vibrating or single stroke bell with a four-inch gong; that the springs carrying contacts be of non-corrosive metal and that the armature bearings be of non-corrosive metal of the trunnion type; that the contacts be platinum to platinum and that the stroke of the armature be adjustable; that the coils be made in accordance with requirements for coils in R. S. A. specifications for direct current relays and that an insulation equivalent to not less than ⅜-in. air



Drop Annunciator Group
The Railroad Supply Co.

space be provided between any part of the bell-carrying current and any other metal part, the insulation to withstand a test of not less than 3,000 volts a. c. applied for at least two seconds.

The visual indicating annunciators consist of magnet coils having a specified resistance, depending upon the type of circuit and the standards of the road, arranged with an indicator or banner operated

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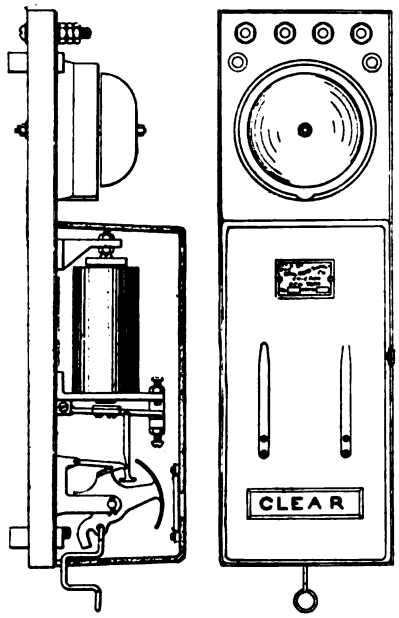
by the armature so that when the coils are energized the armature, on picking up, releases the indicator drop; or the armature may operate a small semaphore arm, disc or pointer. The annunciator circuits may be of the normally closed or normally open type. Annunciators of the drop type may be equipped with a mechanical restoring rod or an electrical resetting coil by means of which the banner may be reset from any part of the tower by means of a push button. An audible device such

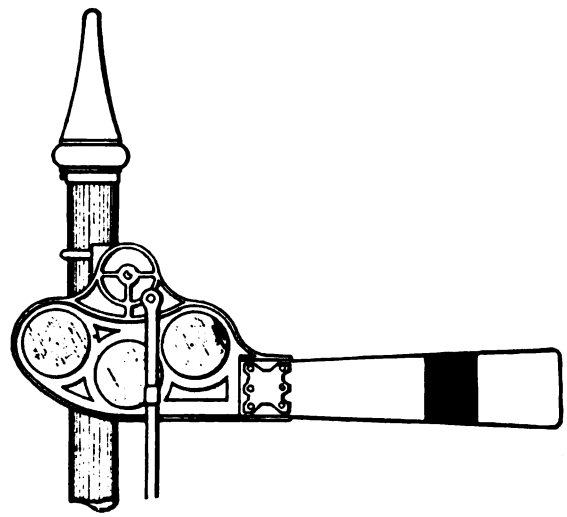


Everett Type Drop Annunciator
The Railroad Supply Co.

as a bell or buzzer may be used in connection with the usual indication operated by contacts in the annunciator, a stick relay or a hand switch with lever contacts being used to silence it after the towerman has heeded the indication, in order that it will not prove a nuisance and be plugged to prevent its operation. On tracks where traffic is in both directions the annunciator should work only on the approach of a train; one way of accomplishing this is by the use of interlocking relays. See Stick Relay. Also Relay, Interlocking.

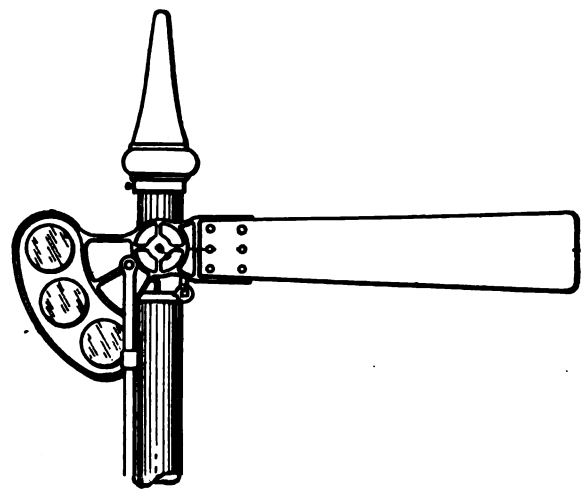
ARM (Semaphore). The principal movable part of a semaphore, consisting of a blade of wood or metal fastened to a casting which turns on the supporting pivot and is used to show the engineman the condition of a block or route. The information may be conveyed by the arm working in two or three positions in the upper or lower right hand quadrant, or in some cases, as on electric lines, in the upper left hand quadrant, usually because of the interference of a pole line.

The standard R. S. A. semaphore spectacle consists of cast iron or a cast iron hub with the spectacle holders of No. 12 United States standard gage sheet steel while the standard signal blades are of wood 3 ft. 6 in. long with square or pointed end blades as the circumstances require. The blade for a slow speed (heretofore called "call-on") signal at an interlocking plant is 2 ft. 6 in. long. All blades are ¾ in. thick, 7 in. wide where attached to the casting and tapering to 8⅞ in. at the end



Upper Quadrant Interlocking Semaphore Arm

for the slow speed arm, 9⅝ in. for the home signal arm and 9⅛ in. for the automatic signal arm. Each has a metal reinforcing cleat on the back, located



Lower Quadrant Semaphore Arm

9 in. from the end on a long arm and 6 in. from the end on a short arm. The R. S. A. drawing specifies that the front be painted red with a white stripe or yellow with a black stripe 7 in. wide on the long arms and 5 in. wide on the short arm, while the backs and edges are to be painted black.

ARM CASTING (Semaphore). That part of a semaphore arm which contains the bearing and spectacles holding the roundels and used to support the wood or metal semaphore blade and to hold the glasses which give the night color indications corresponding to the position of the arm for the day indications.

One design adopted by the R. S. A. consists of an iron casting containing openings for holding roundels 8⅜ in. in diameter. Another standard con-

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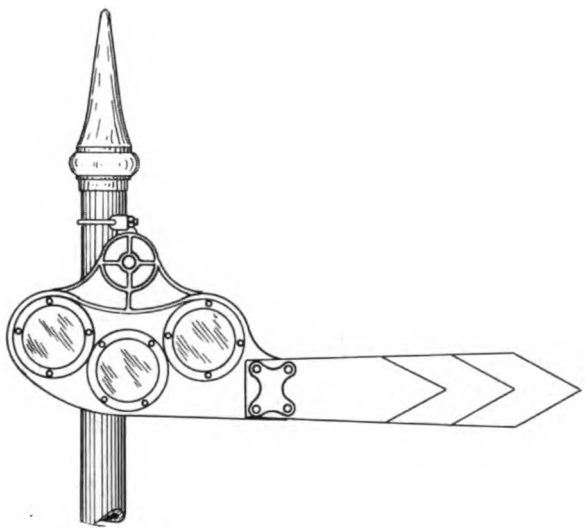
sists of a cast iron hub to which is fastened the spectacle which is made from No. 12 United States standard gage sheet steel, and which holds the colored roundels and arm. The R. S. A. standards require that a minimum clearance of ¾ in. shall be maintained between the semaphore bearing and any passing part of the semaphore spectacle except the hub, and that 1 in. minimum and 2 in. maximum



R. S. A. Arm Casting, Showing Automatic Semaphore Blade Attached

clearances shall be maintained between the lamp and any passing part of either front or back spectacle castings. This provision is made to prevent the casting from catching on any fixed part of the signal and thereby preventing its proper operation, thus causing a false clear or other signal failure.

ARM SWEEP (Semaphore). The segment of a circle defining the limits of the movement of a semaphore signal arm. A sweep of 45, 60 or 90 deg. is employed for lower quadrant signals and 45 to 90 deg. for upper quadrant signals. See Arm (Semaphore).

ARMATURE. A mass of iron or other magnetizable material placed on or near the pole or poles of a magnet, completing the magnetic circuit.

In signal apparatus such as d. c. relays, the armature is used to actuate contacts for opening and closing electrical circuits or in connection with the operation of magnetic clutches in signal mechanisms, etc. In the case of a permanent magnet the armature may be of soft iron, placed directly on the magnetic poles, in which case it preserves or keeps the magnetism by closing the lines of magnetic force of the magnet through the soft iron of the armature. It is then called a keeper. In the case of an electro-magnet the armature is placed near the poles, as for example in direct current signal relays. The armature is moved toward the poles whenever the magnet is energized by the passage of the current through the magnetizing coils. This movement is made against the action of a spring or gravity, so that on the loss of magnetism by the magnets the armature moves from the magnetic poles. When the armature is of soft iron it moves toward the magnet on the completion of the circuit through its coils, no matter in what direction the current flows, and it is then called a non-polarized or neutral armature. When made of steel or another electro-magnet it moves from or toward the poles according to whether the poles of the armature are of the same or of a different polarity from those of the magnet. Such an armature is called a polarized armature (Houston). The term armature is also applied to the rotor or stator of a motor or generator. See Lines of Force. Also Relay. Also Relay, Neutral. Also Relay, Polarized.

AUTOMATIC STOP. Apparatus designed for installation jointly along the roadway and on trains, which, working in conjunction, will, under certain conditions, automatically make a brake application until the train has been brought to a stop. It is designed to enforce obedience to signal indications if the engineman should for any reason overlook them or become incapacitated and should also be so designed as to convey to a moving train the conditions existing on the track ahead. The apparatus may be of some form of mechanical, electro-magnetic, inductive or wireless type. See Automatic Train Control.

AUTOMATIC TRAIN CONTROL. Apparatus designed for installation jointly along the roadway and on trains which, working in conjunction, will under certain conditions automatically (1) make a brake application until the train has been brought to a stop, or (2) make a brake application until the speed of the train is reduced to a predetermined rate when this rate is being exceeded, or both. The use of automatic train control is to enforce obedience to signal indications if the engineman should for any reason overlook them or become incapacitated.

Ramp of Intermittent Contact Type of Train Control
The Miller Train Control Corporation

Requisites for the design and construction of automatic train control devices which were drawn up by the Automatic Train Control Committee of the United States Railroad Administration stipulate that:

1. The apparatus shall be so constructed as to operate in connection with a system of fixed block or inter-

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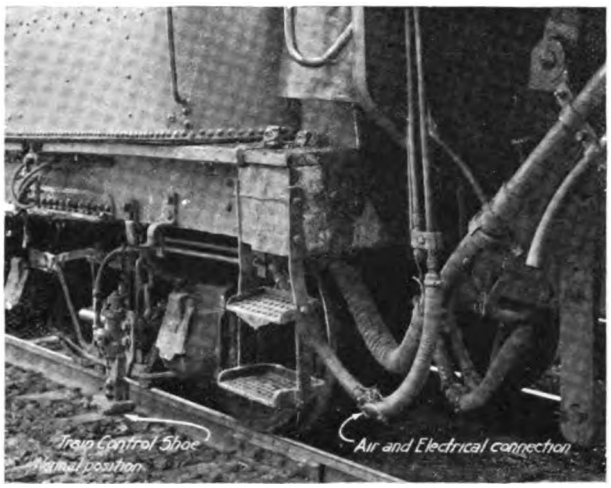
locking signals, and so interconnected with the fixed signal system as to perform its intended functions; (a) in the event of failure of the engineman to obey the fixed signal indications, and (b) so far as possible when the fixed signal fails to indicate a condition requiring an application of the brakes.

2. The apparatus shall be so constructed that it will perform its intended function if an essential part fails



Shoe, Electrical and Air Connection on Engine Equipped with Intermittent Contact Type of Train Control
The Miller Train Control Corporation

or is removed; or a break, cross, ground or failure of energy occurs in electric circuits, when used.

3. The apparatus shall be so constructed as to make indications of the fixed signal depend upon the operation of the track element of the train control device.

4. The apparatus shall be so constructed that proper operative relation between those parts along the roadway and those on the train will be assured under all conditions of speed, weather, wear, oscillation and shock.

5. The apparatus shall be so constructed as to prevent the release of the brakes after automatic application, until the train has been brought to a stop, or its speed has been reduced to a predetermined rate or the obstruction or other condition that caused the brake application has been removed.

6. The train apparatus shall be so constructed that, when operated, it will make an application of the brakes sufficient to stop the train or control its speed.

7. The apparatus shall be so constructed as not to interfere with the application of the brakes by the engineman's brake valve or to impair the efficiency of the air brake.

8. The apparatus shall be so constructed that it may be applied so as to be operative when the engine is running forward or backward.

9. The apparatus shall be so constructed that when two or more engines are coupled together or a pusher is used it can be made operative only on the engine from which the brakes are controlled.

10. The apparatus shall be so constructed that it will operate under all weather conditions which permit train movements.

11. The apparatus shall be so constructed as to conform to established clearances for equipment and structures.

12. The apparatus shall be so constructed and installed that it will not constitute a source of danger to trainmen, other employees, or passengers.

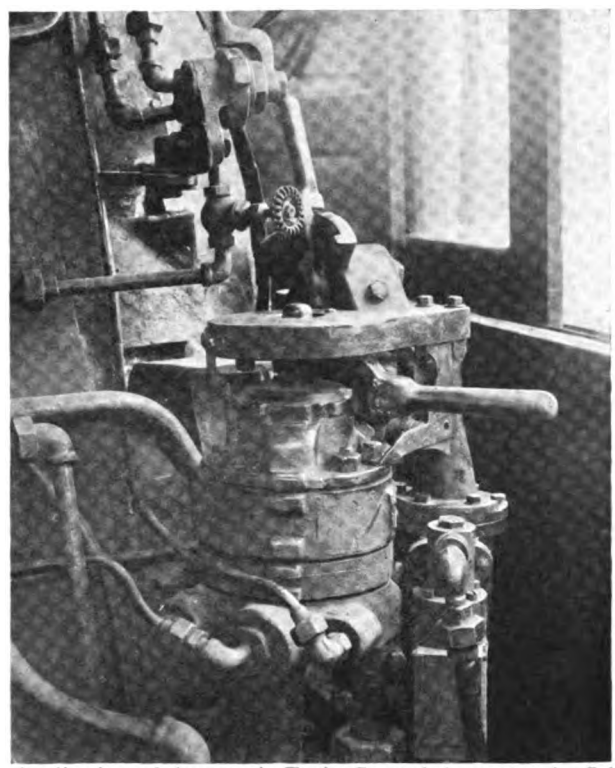
Automatic train control must be designed to convey to a moving train the conditions existing on the track ahead (which necessitates roadside apparatus) and to control the trains in obedience to the indication given (which requires suitable mechanism on the train which must function properly with the roadside apparatus).

The essentials of automatic control are:

(a) Reliability in operation, (b) ease of inspection, maintenance and test to insure efficiency, (c) clearance (relation between parts of the device and obstructions on the roadside or train), (d) capacity (the effect upon the traffic handled over a given section of railroad), (e) interchangeability as between different devices on tracks used jointly by two or more railroads, (f) correlation with track circuit controlled block signaling and air brake apparatus. To secure satisfactory operation, close attention must be given to the proper location of train or roadside apparatus as clearances are affected materially by tunnels, bridges, station platforms, track pans, grade and highway crossings, etc.

Automatic train control is an adjunct to the block system to compel proper observance of the signal indications. The design must be such that the apparatus may be superimposed upon the signal system without interfering with its performance; while the engine equipment must not interfere with the proper operation of the air brake system and must be adapted for use with that system. The logical field for the installation of automatic train control apparatus is on busy lines already equipped with automatic block signal systems.

The Automatic Train Control Committee expressed the opinion that some form of speed control apparatus in connection with a train control



Application of Automatic Train Control Apparatus in Cab of Locomotive
The Miller Train Control Corporation

device is required on lines where trains are operated on close headway (1) to prevent a predetermined speed being exceeded regardless of track conditions, (2) permitting a train to proceed at a predetermined

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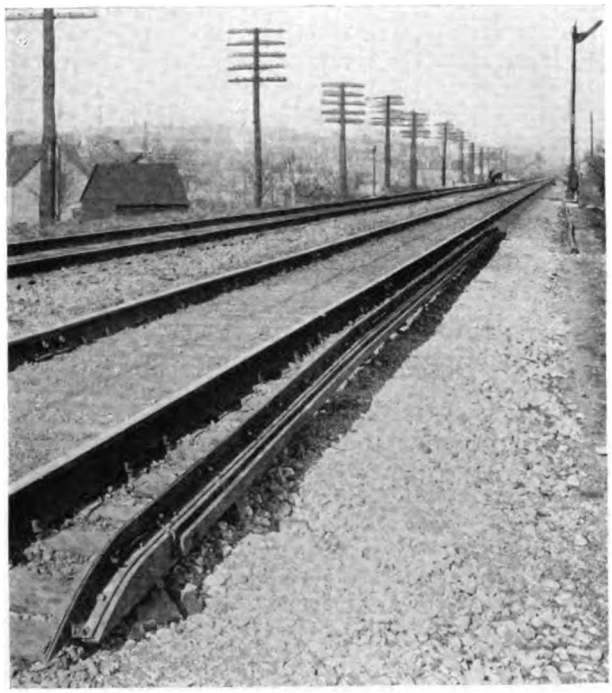
low speed after having been stopped by an automatic brake application, (3) to permit a train to pass a brake application point at a predetermined speed



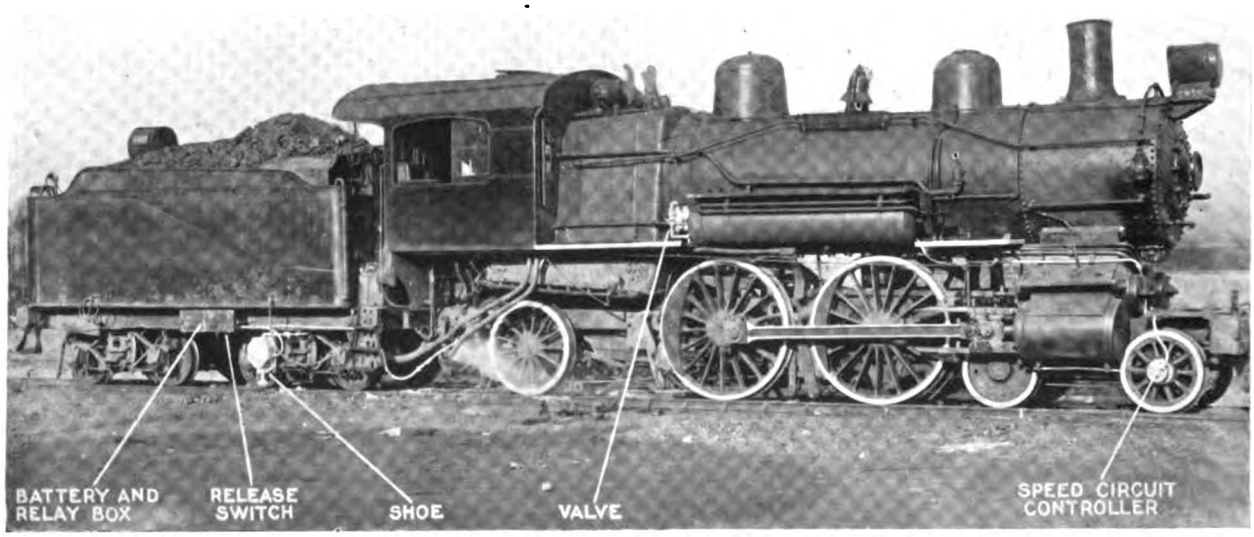
Ramp of Intermittent Contact Type of Train Control
The Regan Safety Devices Co., Inc.

without receiving an automatic brake application (4) to permit a train to pass an approach indication point without a brake application if the enginemen observes the indication properly, (5) to permit a train to proceed without a brake application as long as the train speed is controlled in accordance with the signal indications.

Train control devices may be classified under two general kinds of control, the intermittent and the continuous, and each in turn may be further subdivided under two general types; the contact type and the non-contact type. The first type depends for its operation on a physical contact between the train element and the roadside element while the latter type depends on an electrical or magnetic impulse without physical contact between the train element and roadside element. A complete classification, prepared by the Automatic Train Control Committe, is shown in the accompanying table:

Character of Control	Class of Device	Type of Device
I. Intermittent.	A. Contact.	1. Plain mechanical trip. Ground or overhead.
		2. Electrically controlled mechanical trip. Ground or overhead.
		3. Intermittent electrical contact.
	B. Track rail contact.	1. Insulated truck with short track circuit section.
	C. Non-Contact.	1. Induction.
		2. Inert roadside element.
		3. Non-magnetic rail.
II. Continuous.	A. Contact.	1. Third rail or special conductor.
	B. Non-Contact.	1. Induction.
		2. Wireless.

Devices having intermittent control require roadside apparatus located at certain predetermined points for the operation of the engine apparatus, the indication received at one of these locations governing the operation of the train to the next location. This type of control may consist of the contact or non-contact class. The plain mechanical trip type utilizes a movable roadside contact element which is brought in range with the train apparatus when a



Engine Equipment of Automatic Train Control of the Intermittent Control Type
The Regan Safety Devices Co., Inc.

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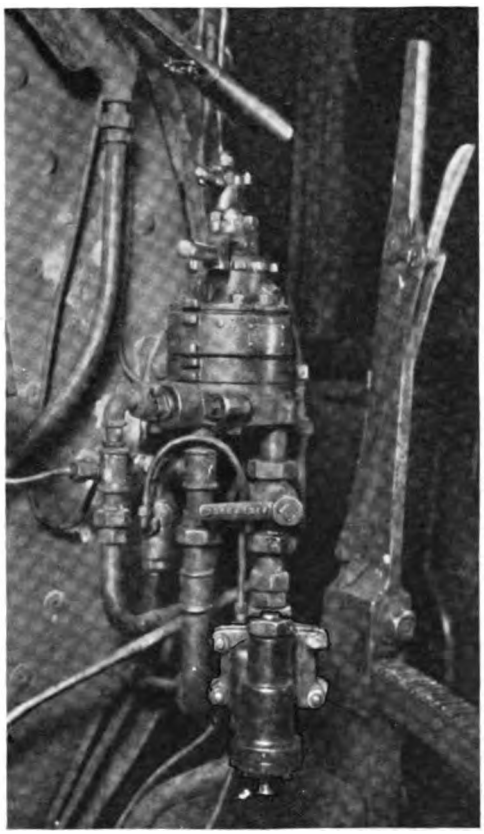
stop should be made, while in the electrically controlled mechanical trip type the roadside equipment is controlled electrically, but the trip itself may be operated by another source of power, as for example compressed air. The intermittent electrical contact type is designed to put the train apparatus in an operative condition at each indication point and is commonly known as the "ramp" type. This type necessitates the train apparatus being kept in the proceed position if the block ahead is clear. Installations of this type are in service on a more or less extensive scale on certain sections of three steam roads and it has been more extensively developed than other types of train control. Another type of



Pneumatic Stop Valve on Locomotive
The National Safety Appliance Co.

intermittent control utilizes a short track section instead of a roadside element, while the wheels on an insulated truck of an engine act in place of an engine contact device.

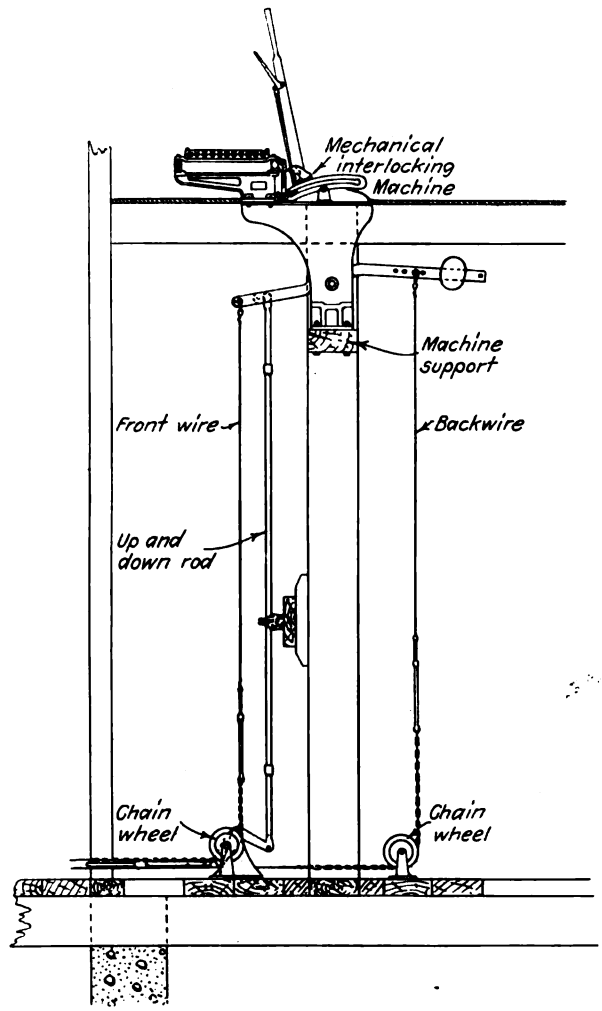
The induction type of the non-contact class of intermittent control employs both permanent and electro-magnets for the roadside apparatus, the magnetic field of the permanent magnets actuating the engine apparatus producing a stop unless this field is deflected or neutralized by the electro-magnets which are energized if the block is clear. Only one device of this type has been tested in service. Another induction type employs a fixed and inert roadside element for reducing the current flowing through a coil on the train, thus actuating apparatus to stop the train. This type is in the laboratory stage of development. A third inductive type makes use of a non-magnetic rail, such as manganese steel, inserted in the tracks at the indication points. But limited tests of this type have been made.

Apparatus of the continuous contact type utilizes a continuous conductor with which the train contact element must remain in contact, the conductor being usually of a lighter section of rail than used in the tracks. The engine apparatus may be similar to that used for the intermittent electrical contact type.

The continuous non-contact induction type utilizes either the running rails of the track or special conductors along the roadside. Alternating current circuits and apparatus are required to amply the current transmitted to the trains. The wireless type of continuous control is in progress of development, practically all of the work being of a laboratory nature.

B

BACK WIRE. A wire connected to the back tail lever of the operating machine to pull a signal to the stop position. It is used to insure that the move-



Cross Section of Mechanical Interlocking Machine Showing the Front and Back Wires of Vertical Leadout and Other Parts

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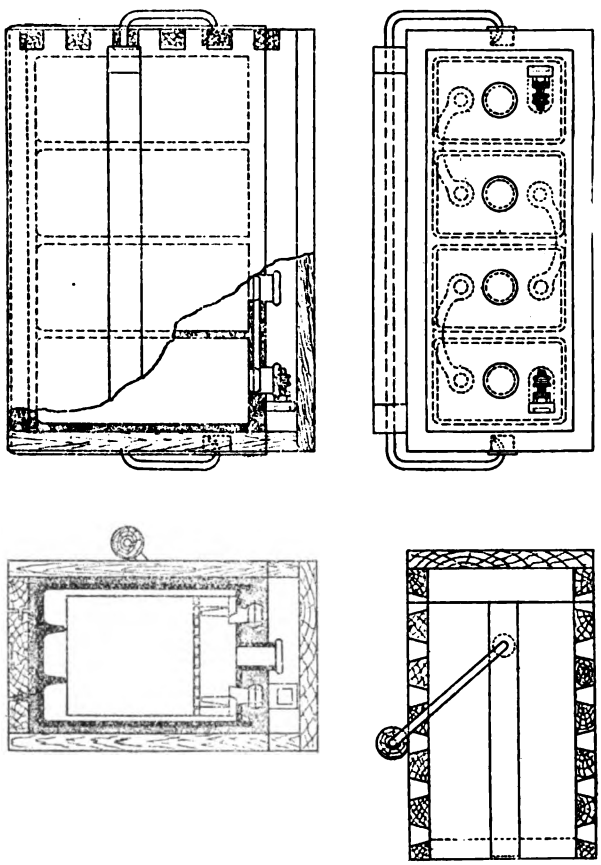
ment of the signal arm to the usual position shall follow the movement of the lever to the position. It is also employed in connection with wire-connected distant switch signals. This is sometimes called the down-pull wire.

BATTERY. Two or more primary or secondary cells with the positive element of one cell connected to the negative element of the next cell (series connection) or with the positive element of one connected to the positive element of another and the negative element of the first to the negative element of the second (multiple connection) or one or more cells connected in series and then connected in multiple with other sets of cells. (Multiple-series connection). The word battery is often erroneously used in speaking of one cell. The term signal battery means the combination of two or more cells for the operation of signal circuits. See Cell.

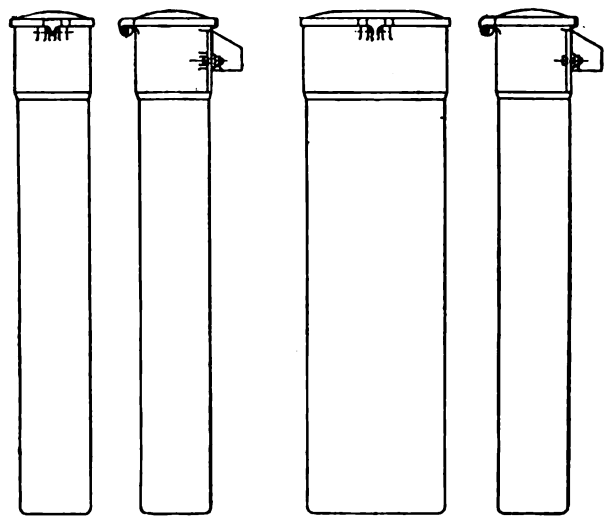
BATTERY, PORTABLE. One or more cells mounted conveniently as a unit for handling. The number of cells should be limited by the maximum weight desired. If the number in one unit is not sufficient to obtain the working voltage, additional units are connected in series. The size of the cell is



R. S. A. Lead Type Portable Storage Battery

determined as in a stationary battery. The plates should be of minimum weight consistent with reasonably long life. They are assembled in groups and elements, and mounted in a suitable container to reduce the chance of breakage to a minimum. No metal connections other than lead should be exposed in order to prevent corrosion from acid and all metal connections should be so arranged as to reduce corrosion from this cause. These cells are used extensively for the operation of automatic signals and at interlocking plants for the operation of the signals, and auxiliary apparatus. See Cell, Storage.

BATTERY CHUTE. A small receptacle for batteries, designed to be set in the ground below frost level in order to prevent freezing of the battery. Chutes are usually circular or oval and may hold one or two tiers of batteries of two to four cells per tier. They are commonly made of cast iron and sometimes of re-inforced concrete or fiber. Battery chutes are from 5 ft. to 9 ft. in length, the single



Single and Double Battery Chutes

chutes are 9⅜-in. inside diameter and the double chutes, 19¼-in., the cast-iron chutes having ⅜-in. walls. The longer chutes are used in those parts of the country where extreme cold is encountered in order to place the battery below the frost line. They are employed principally for housing track circuit batteries in connection with direct current track circuits. See Battery Well.

BATTERY JAR. A jar which holds the electrolyte and the positive and negative elements of each of the separate cells of a primary or secondary battery. The jars for signal service may be circular or rectilinear in shape and made of glass, heat resisting glass, porcelain or hard rubber.

The gravity cell jar is generally cylindrical with ¼-in. walls, 6-in. high by 8 in. inside diameter and made of machine-moulded glass. The jar for the Lalande cell is cylindrical or rectilinear and made of glass, heat resisting glass or porcelain. Round jars range in size from 6⅜-in by 8½-in. to 6½-in. by 12⅞-in. The R. S. A. specifications call for a round, heat resisting glass jar.

Storage battery jars are rectilinear in shape, of glass for the stationary type (except for the nickel-oxide alkaline type which is made from nickel-plated sheet steel), and hard rubber for the portable type. The stationary glass storage battery jar ranges in size from 4¾ in. by 7⅛ in. by 11 in. for the 40 am-

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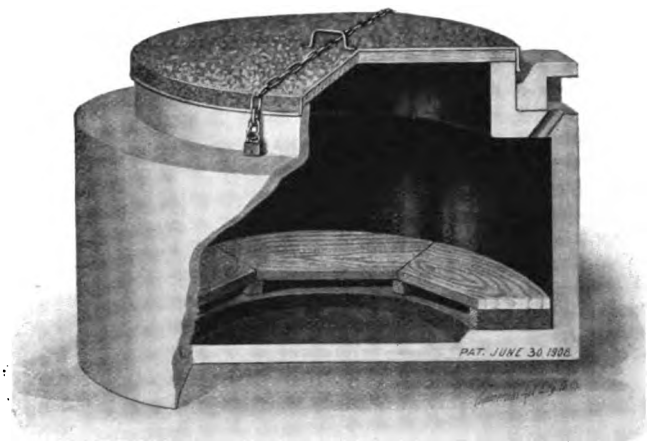
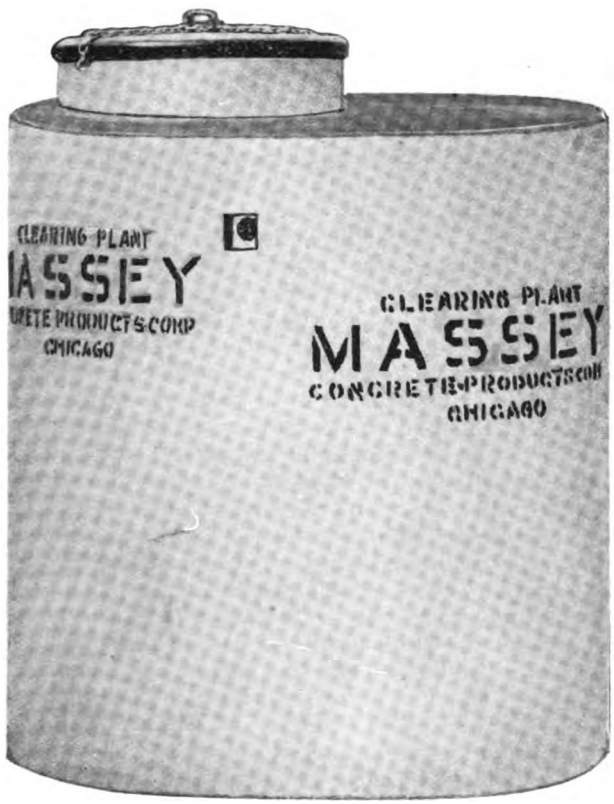
pere hour cell to 10⅝ in. by 12⅜ in. by 17 in. for the 400 ampere hour cell. The containers for the portable cells are also of various sizes, depending upon the capacities of the cells.

BATTERY WELL. A large receptacle for housing a number of primary or secondary cells or both



Shallow Battery Well
The Massey Concrete Products Corporation
(See Page 743)

below the frost line. It is usually made of concrete and occasionally of masonry, wood or boiler plate, generally being monolithic and sunk in place.



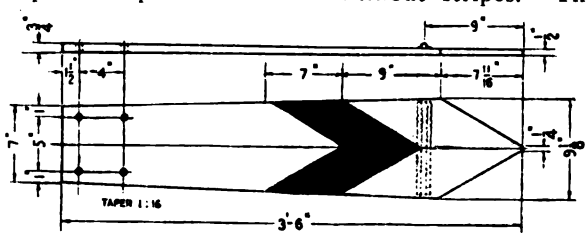
Signal Cellar. Combination Battery Housing and Signal Foundation
Massey Concrete Products Corporation
(See Page 743)

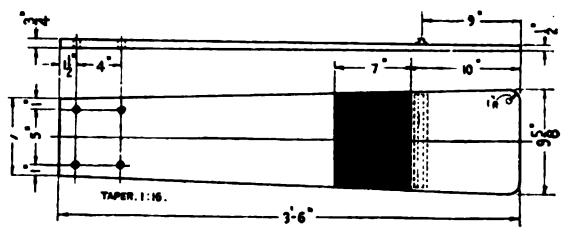
Battery wells are used for housing signal operating and circuit batteries and batteries for highway crossing signals and are usually located at or near signal locations. They are manufactured to hold from 16 to 96 R. S. A. cells. See Battery Chute.

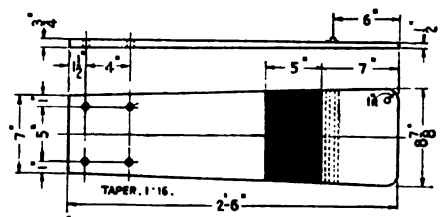
BELL CODE. A code indicating the number of strokes of an electric bell to be sounded to convey information from one block station to another for the necessary communication in manual block signaling. See Block System, Manual.

BLADE, SEMAPHORE. The extended part of the signal arm which gives the day signal indications of a semaphore signal.

The blade may be of wood or metal of various shapes and painted with or without stripes. The







R. S. A. Automatic Signal Blade; High Interlocking and Low Speed Blades

blade is fastened to the semaphore casting. See Arm (Semaphore). Also Arm Casting (Semaphore). (See Page 803).

BLADE GRIP (Semaphore). That part of the arm casting which is formed to receive the blade and to which the blade is fastened. See Arm Casting (Semaphore).

BLOCK. A length of track of defined limits the use of which by trains is governed by block signals. (A. R. A.) The term is commonly used for a block section. See Block Section.

BLOCK INSTRUMENT. The instrument used in controlled manual block signaling to compel the co-operation of block operators at both ends of the block in allowing a train to enter from either end. The arrangement is such that this can be done only when the block is clear. See Block System, Manual.

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BLOCK OPERATOR. The attendant at a block station (in manual block signaling), who also frequently performs the duties of switchman and telegraph operator. See Block System, Manual.

BLOCK SECTION. A section of track of defined limits, the use of which by trains is regulated by a fixed signal at the entering end; or on a single track line by such signals at both ends.

In automatic signal territory a block section may range from a few hundred feet to three or more miles in length while in manual block signaling it may vary from about ½ mile to 20 or more miles in length. the average block section being about 7 miles. See Signal, Fixed.

BLOCK SHEET. A sheet kept at a block station on which the movement of trains is recorded as affecting that station. See Block System, Manual.

BLOCK SIGNAL, AUTOMATIC. A block signal which is controlled by the passage of a train into, through or out of the block section which it may govern. It is used to indicate to an engineman the condition of the block governed. The entrance of a train into the block will set the signal governing the entrance to the block at stop and the clearing of the block section by the passage of the train out of it allows the signal to clear automatically. The apparatus is so arranged that the misplacement of a switch or the accidental entrance of a car from a side track into the block section, a broken rail or similar conditions will set the signal at stop automatically. Automatic block signals are of several different types as the semaphore, the position light, the color light, and the disc signal and are almost universally operated by electricity. See Block System, Also Track Circuit.

BLOCK SIGNALING, ABSOLUTE. A system of block signaling based on the fundamental principle of the block system that no train shall be admitted to a block while another train occupies it. See Block Signaling, Permissive.

BLOCK SIGNALING, PERMISSIVE. A system of signaling permitting one or more trains moving in the same direction to enter a block section before the last preceding train has passed out.

Under this system a following train is allowed to proceed with the expectation of finding the track blocked and must be prepared to stop before reaching any obstruction without being warned by a flagman or otherwise. In manual block territory permission to proceed is given by a written card from the block operator; by a permissive signal indication (generally with the semaphore arm in the 45 deg. upper or lower quadrant position when this type of signal is used); or by flag or hand lantern in some cases. In the manual block system the permissive indication is allowed to be given to trains other than passenger, to follow each other into a block in order to facilitate the movement of traffic while avoiding the expense of maintaining shorter block sections. Absolute blocking however is usually enforced before and behind passenger trains. Provision is made in the Standard Code of the A. R. A. for permissive blocking under the controlled manual block system.

The automatic block signal system is essentially a permissive scheme for otherwise if a signal was out of order and indicating stop, the line would be blocked until the signal could be repaired. The Standard Code provides that at other than the stop and stay signals, a train, on coming to a signal in the stop position must first stop, then proceed. On single track railways, however, using the overlap scheme of signaling it is generally customary for a train, on coming to a stop signal, to wait long enough for a flagman to precede at a safe distance in advance, the train following at low speed under his protection as the signal may indicate stop because of the presence in the block of an opposing train.

In the absolute permissive block scheme of single track signaling in which protection against opposing moves is obtained from passing siding to passing siding with a stop and stay signal controlling the outgoing end of the siding, and with a telephone location connected to the telephone train dispatching line, the general practice is that if the stop and stay signal indicates stop, it must not be passed in this position without authority from the train dispatcher. However, if the trainman should be unable to communicate with the train dispatcher, the train may proceed under the protection of a flag to the next block signal found at proceed or caution, provided time table and train order authority permit. If a train is stopped by a permissive or intermediate automatic signal after having received a clear or caution indication at the absolute automatic signal, it may proceed with caution expecting to find a train in the block, a broken rail, an open switch or other obstruction.

In multiple track automatic block signal territory the general practice, when a train receives a stop indication is for it to stop, then proceed expecting to find a train in the block, an open switch, broken rail, etc. See Block System, Manual. Also Block Signal System, Automatic. Also Permissive Card. Also Caution Card.

BLOCK SIGNAL SYSTEM, AUTOMATIC. A series of consecutive blocks governed by block signals operated by electric, pneumatic or other agency actuated by a train, or by certain conditions affecting the use of a block (A. R. A.).

This system, the fundamental feature of which is the track circuit, is employed to provide a space interval between trains the operation of which is directed by time table, train despatching, train orders and train order signals and the block system. The space intervals are called blocks and may vary in length from a few hundred feet to two or more miles, the average length of block being about one mile. In this system, on tracks signaled for one direction, a signal automatically assumes a stop position as the train passes it and remains in this position until the train reaches the next signal which then assumes the stop position and so on while the first signal goes to the caution or clear position. On tracks signaled for train operation in both directions the same object is attained and in addition signals governing movements in the opposing direction display a stop indication, some distance ahead of the train or from one station to the next, depending upon the scheme of signaling employed.

The operation of this system of signals depends upon the track circuit which consists essentially of a source of electricity (in the form of primary or sec-

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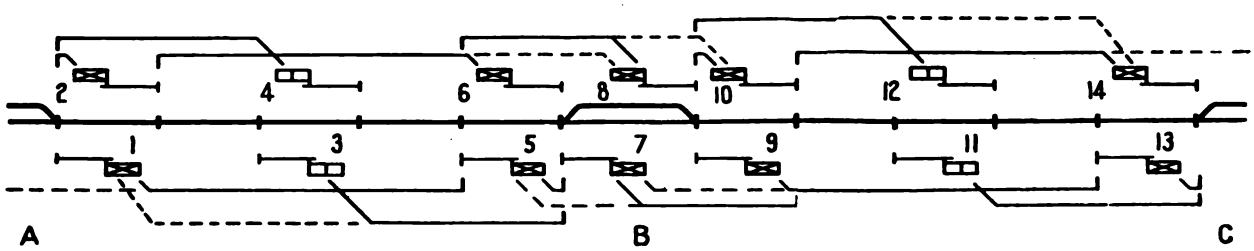
ondary cells or a source of a. c. power supply) connected across the two rails to furnish current which is carried by the rails, made into a continuous conductor by means of bonds which bridge the rail joints, to the end of the track section where other leads of insulated wire make an electrical connection between the rails and an electro-magnet or other operating device (relay) which operates a number of electrical contacts controlling the signal operating circuits. For direct current circuits the rails are divided into sections averaging about 2,500 to 3,000 ft. in length by means of insulated joints, each section forming a complete closed circuit and having its own source of energy and its operating device (relay). For alternating current track circuits the lengths of sections can be as great as three miles or more.

In any automatic signal system the signal indications are controlled by the train passing over the track sections. When a train enters a section the wheels and axles form a conducting path from one rail to the other, because of their low resistance as compared to the relay, thereby allowing the greatest part of the current to flow from one rail through them to the other rail and back to the source of current supply. This reduces the current strength at the relay to such an extent that the contacts controlling the signal operating circuits open, causing the signals to assume their most restrictive indication back of a train until it has passed out of the block section (which may consist of one or more track sections).

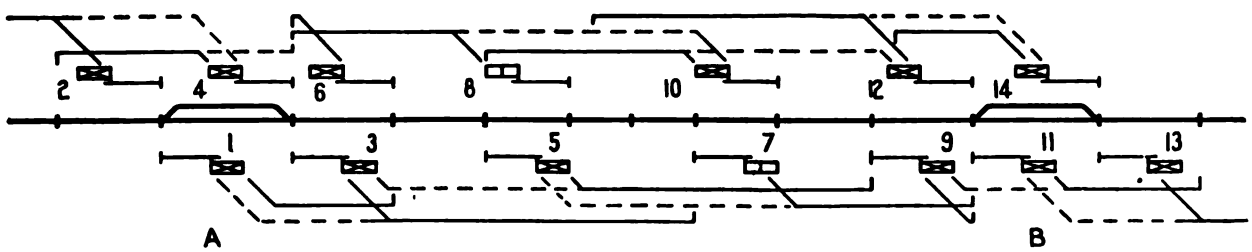
Two systems of signaling are principally employed in automatic block work—direct current and alternating current. The direct current system employs primary or secondary cells or both types for the operation of the track circuits and the signals, the signals operating at about 10 volts while approximately 1 volt is applied to the track circuits. Where power interlocking plants are located in d. c. automatic signal territory, the interlocking signals, which are generally a part of the automatic block signal system, are usually operated on 110 volts. The alternating current system employs an a. c. transmission line with necessary power houses, substations and allied equipment throughout the signal territory, the transmission lines generally carrying a voltage of 4,400 or under, which is usually transformed down to 110 volts for signal operation while track transformers reducing the 110 volt a. c. current to from 1 to about 20 volts for track circuits (and low voltage signal lighting if used) are utilized for furnishing energy to the track.

Automatic Block Signals on Double Track



Overlap Scheme of Signaling with One Pair of Signals Between Sidings

Automatic block signaling may be further classified as single and multiple track signaling. D. c. signals are operated as a normal-danger or normal-clear system, the normal-clear being the generally recognized standard. Single track signaling may consist



Overlap Scheme with Two Pairs of Signals Between Sidings

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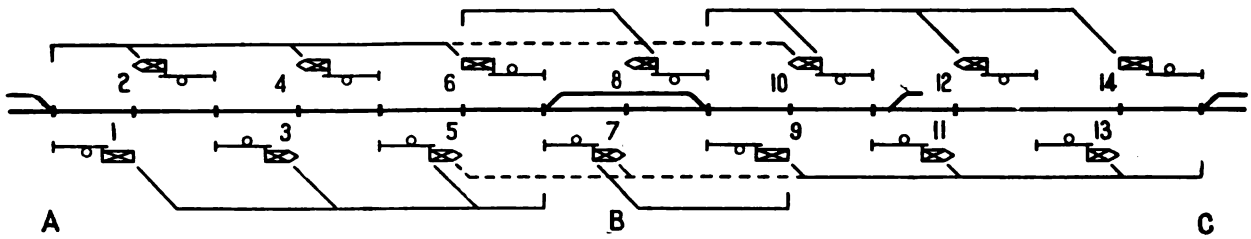
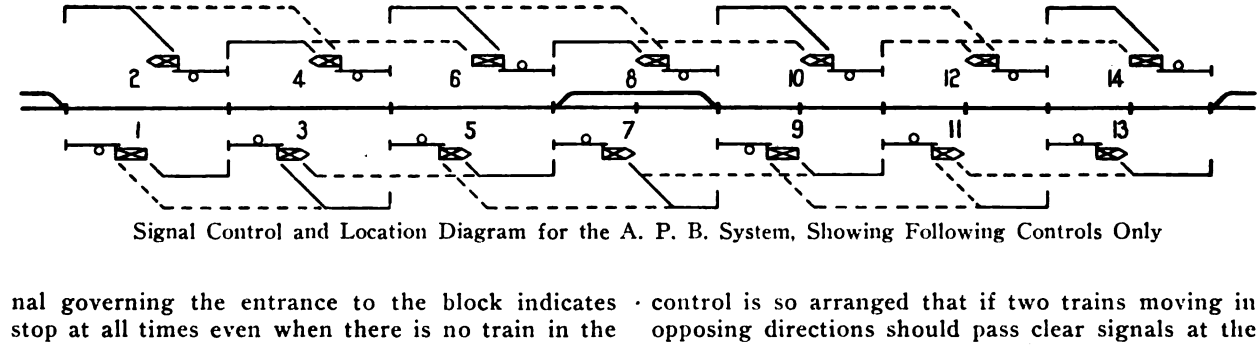


Signal Control and Location Diagram for the A. P. B. System, Showing Head-on Control Only

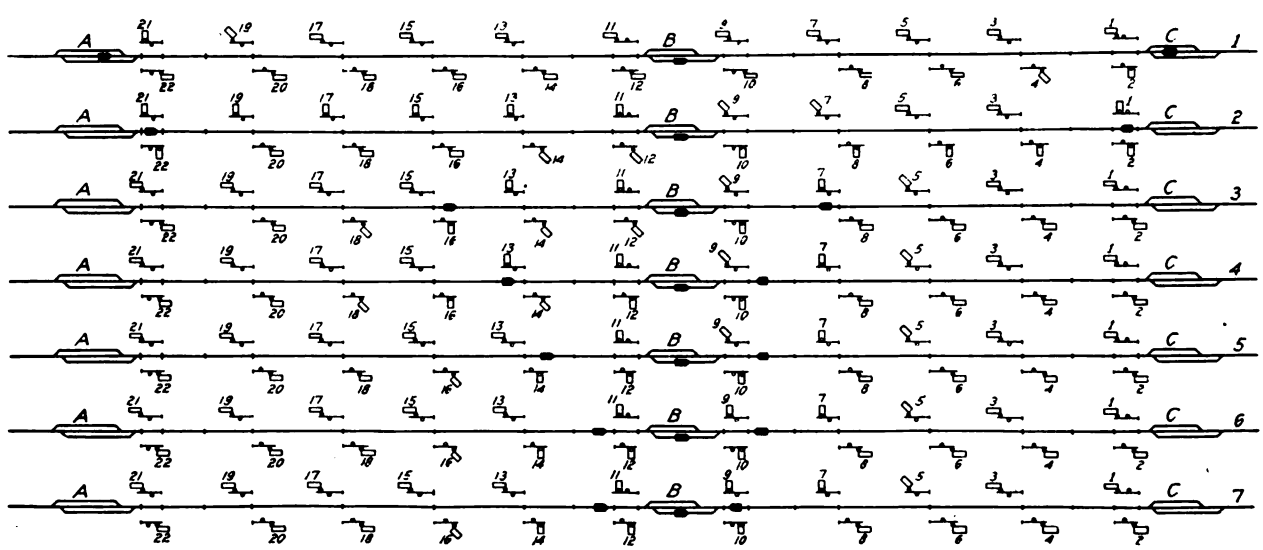
of the straight or overlap scheme which was first developed for this purpose or the "absolute permissive block" scheme in which an absolute block is maintained from a station or passing siding to a station or passing siding against opposing train movements, while permissive or following moves can be made by trains moving in the same direction.

In the normal-danger system of signaling, the signal governing the entrance to the block indicates stop at all times even when there is no train in the block, except when a train is approaching which, (on entering the clearing section from 2,500 ft. to a mile or more to the rear of a signal) will cause the signal to clear, provided the block ahead is unoccupied and the switches are properly lined up, etc. This practice resembles the methods followed in manual signaling where the home signals are always kept in the stop position, except when it is necessary to clear them for the passage of a train. Normal-clear signal systems are so named from the fact that the signals indicated proceed at all times when their block sections are unoccupied with the switches closed and all apparatus in order.

In the overlap scheme of signaling for single track, which was the first to be employed, the track circuit control is so arranged that if two trains moving in opposing directions should pass clear signals at the same instant, other opposing signals are so situated that each train will encounter a stop signal before it can meet the other in a butting collision. This is accomplished by carrying the control circuits for one home signal beyond that next in advance which governs in the same direction, a distance of 2,500 ft. to a mile or more and making the continuity



Signal Control and Location Diagram for the A. P. B. System, Showing Following Controls Only



A. P. B. Signaling, Showing Signal Operation for Two Trains Approaching a Meeting Point. (Chicago & Northwestern Practice)

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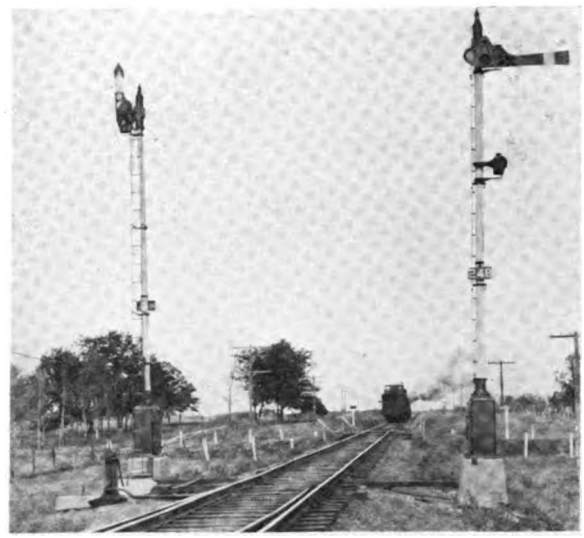
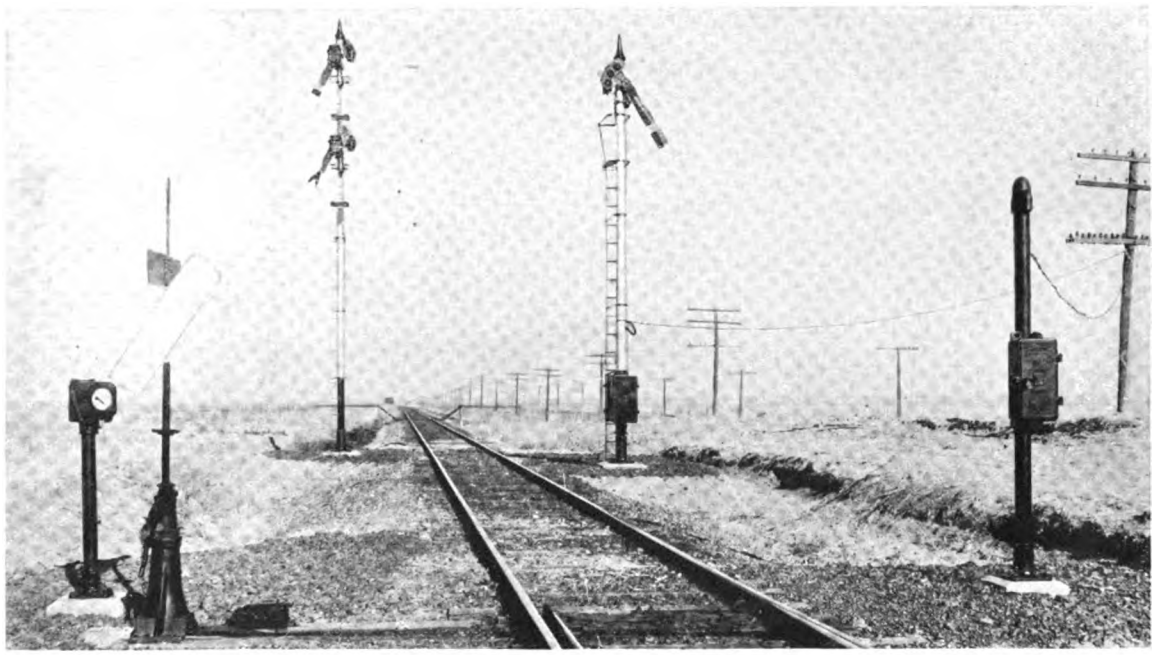
of the circuit dependent upon the condition of the track section or sections ahead of the last named signal. Signals for trains moving in the opposing direction have their control circuits overlapping the next home signal in advance in a similar manner.

Some of the disadvantages of this system are that signal indications will permit two trains to enter the same stretch of track between passing sidings if one of the trains should overlook or mistake a meet order and, while they would be stopped before coming together one would have to back up to get in the clear. Again as overlaps are required only for head-on protection and not for following trains, opposing signals are staggered, thus increasing the length of the block necessary for following train movements. Another disadvantage is the unreliability of the distant signal indications under certain conditions, as with two trains approaching a passing siding, one or in certain instances both trains may receive a clear distant signal indication and will approach the home signals, which in the meantime have assumed a stop position, without being under control. Again, it is felt that the overlap scheme may tend to impair discipline, as, when a signal indicates stop an engineman may feel that it need not be obeyed strictly but that it can be overrun a certain distance because of the overlap, without colliding with a preceding train. Among the advantages are that safety of operation is increased; a reliable means is provided for maintaining a space interval between trains; track capacity is increased materially and "19" orders may be substituted for "31" orders, thus eliminating a number of stops. (The foregoing advantages are applicable to any scheme of automatic block system). In the overlap scheme the distant signal indication can be received at a point a proper distance from the home signal for an engineman to act immediately.



Automatic Block Signal at End of Passing Siding in Absolute Permissive Block Territory

The absolute-permissive-block scheme of single track signaling provides head-on protection from one passing track to another passing track while permitting following movements to be made. The leaving signal at the end of a passing siding is made a positive "stop and stay" signal while the intermediate signals and the entering signals to passing tracks and station limits are permissive signals, which, when in the horizontal or "stop" position indicate "stop; then proceed." Generally, a square end signal blade is used on all positive signals with a marker light located about six feet directly below the signal light, while the permissive signals have



Automatic Block Signaling in Absolute Permissive Block Territory on the Chicago, Burlington & Quincy

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Automatic Block Signaling Showing Distant Signal, Relay Box, Concrete Battery Well and Track Battery Chute.

blades with pointed ends with the marker light located diagonally below the signal light. In operation, this system is arranged so that when a train passes a positive signal at the leaving end of a passing siding or at Station A the opposing positive signal at Station B is set at stop and in addition all opposing intermediate permissive signals assume the stop position, thus hold any opposing train at B until the arrival of the train from A. The opposing signals clear up automatically after the train passes them. At the same time the train is proceeding toward B it is protected from a following movement by a stop and a caution signal back of it. In this system a telephone, connected to the telephone train despatching line, is located at each positive signal, enabling the train crew to be governed by orders from the despatcher should the positive signal be out of order. Some of the objections to this system are that the distant indications cannot always be given at a reasonably uniform distance from the home signal; that the flexibility of station switching is not as great as with the overlap scheme and that this system is a little more complex than the overlap scheme.

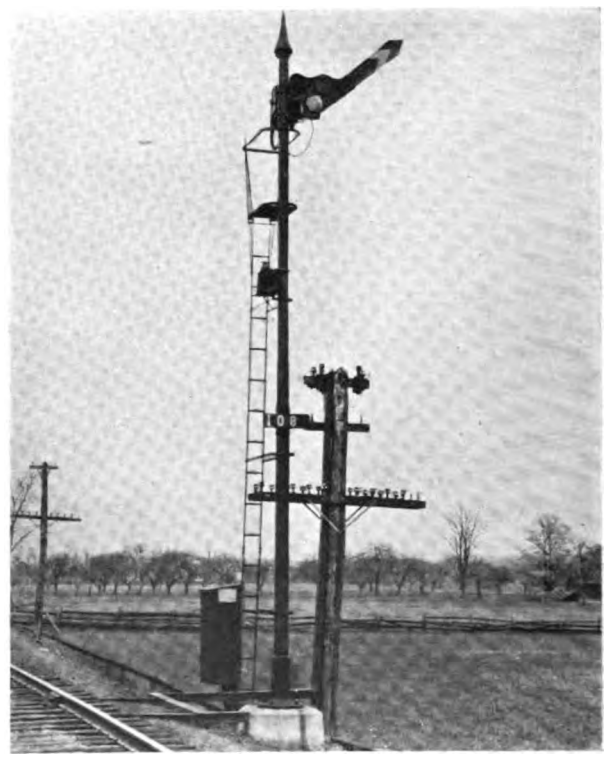
Among the advantages may be mentioned that opposing trains are prevented from entering the same section of single track between sidings; the elimination of the overlap allows following trains to be spaced a less distance apart, thus increasing track capacity; head-on flagging is eliminated except under certain exceptional conditions and a much greater reliability in the distant signal indication results.

Where multiple tracks are signaled for traffic normally in one direction only, a much simpler problem is presented from an operating standpoint and in circuit design than that for single track operation where opposing moves must be prevented. Signals may be spaced with reference to the traffic requirements and generally a stop and a caution signal indication are given back of a train, although in a few cases to meet certain conditions two stops and a caution signal indication may be displayed back of a train.

Alternating current signaling on steam lines is an outgrowth of the requirements of roads using direct current for propulsion. As the rails carried the return current back to the power house other provision than the use of direct current at low voltage had to be made for operating the track circuits if both rails were to be used as a return for the propulsion current and this was finally accomplished by using alternating current in which the track is divided into sections by insulated joints around which are connected balanced impedance bonds. (The first a. c. track circuits that were installed, however, were single rail circuits.)

Unlike the d. c. signals the a. c. signals are generally operated on 110 or 220 volts.

Some of the disadvantages of this system as compared to the d. c. system are that the breaking of the transmission line or the interruption of the power supply puts the entire system out of order beyond the break. The first cost is about one-third greater and a separate pole line is required. Among the advantages are: Track relays are not affected by foreign current; it may be made to anticipate and provide for future electrification of the line; track circuits can be equalized with block sections; less apparatus is required which means less maintenance; signals, stations and similar railway buildings may be electrically lighted from the transmission line; the amount of power available tends to more reliable working under all conditions and the maintenance



A. C. Automatic Block Signaling

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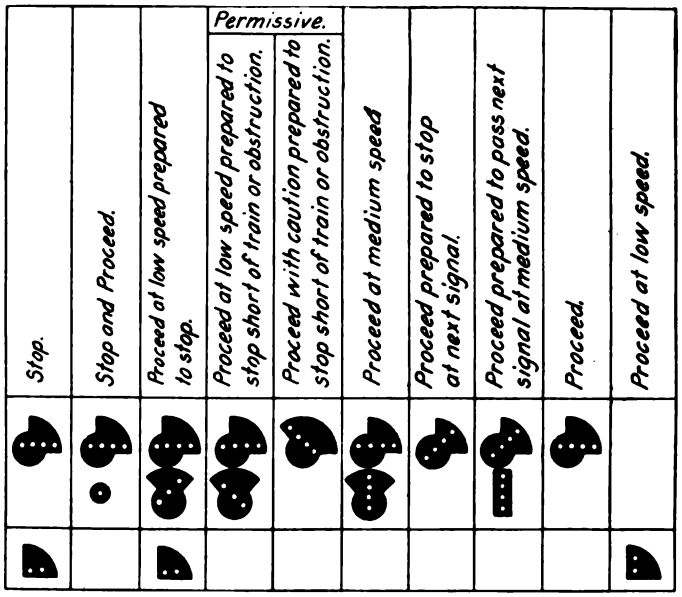


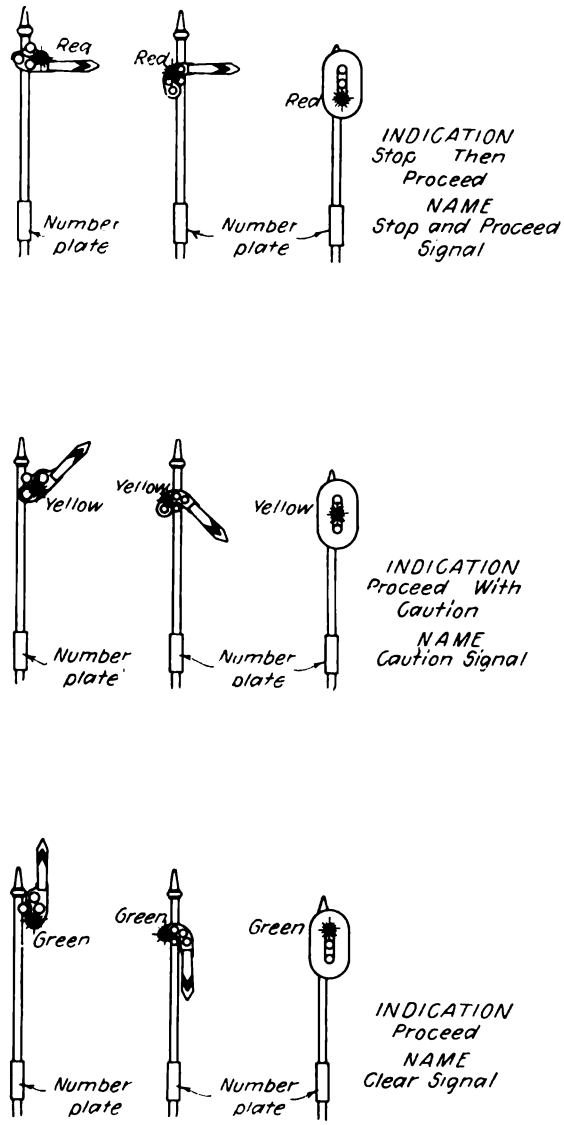
Position Light Signal Indications

force can be reduced as one man can maintain a much longer section of a. c. than of d. c. signaling.

The signals used in automatic block signal systems may be of several different types; as the two or three-position upper or lower quadrant semaphore type, position or color light signals, enclosed disc, electro-pneumatic or electro-gas, the last three being used only to a limited extent. In present standard practice the three position upper quadrant motor semaphore type of signal is more generally used although the tendency is gradually to go to light signals and thereby eliminate a number of mov-

Position Light Automatic Block Signals on the Pennsylvania

ing parts which are required for the motor-driven semaphore signals, thus reducing the chances for mechanical failures. The enclosed disc type was the first to come into general use and was designed as an improvement over the old clock-work signal. This signal however is a color instead of a position signal for both day and night indications. The electro-gas



Three-Position Automatic Block Signal Indications for Upper and Lower Quadrant Semaphore and Color Light Signals on the Chicago, Rock Island & Pacific

semaphore signal is operated by compressed carbonic acid gas admittance of which to the operating piston is controlled by an electro-magnet. In a similar manner the electro-pneumatic semaphore is operated by compressed air which is controlled through an electro-pneumatic valve. Many improvements have been made in the motor-driven electric semaphore type and this is now used in preference to other types because of its simplicity, adaptability and the fact that only one kind of power is required for its operation. Both top-of-mast and bottom-of-mast mechanisms are employed for the operation of the electric semaphore signal. The motor and hold-clear devices are generally supplied with current at voltages of from 8 to 12 from primary or secondary batteries. In clearing a signal arm from the stop to the proceed position through 90 deg. with a maximum semaphore torque of between 30 and 50 ft. lb., approximately 2½ amperes will be consumed while the hold-clear device uses from 8 to 20 mil-amperes de-

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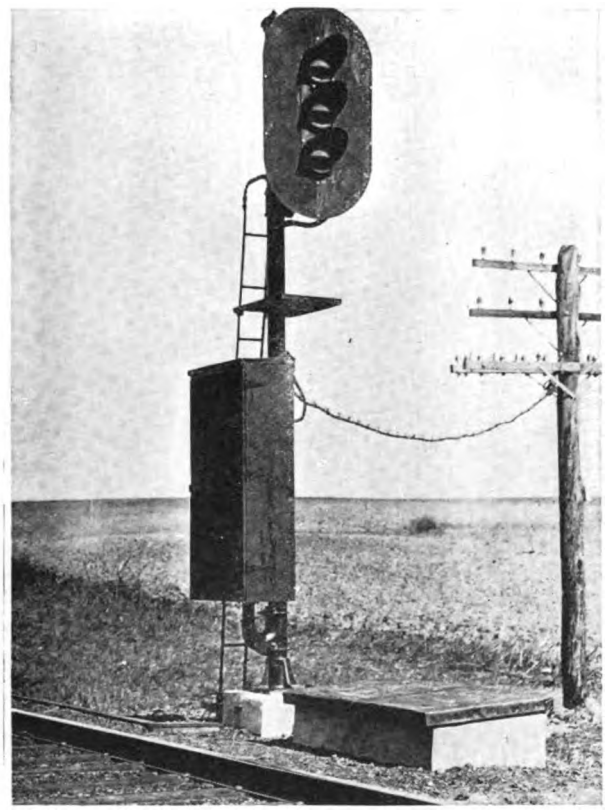
pending upon the voltage and resistance. A. c. motors use about one ampere at 110 volts with an 0.8 power factor, induction motors require from 2.5 to 3.5 amperes at 110 volts with about a 0.5 power factor, while the hold-clear devices require from 5 to 10 watts depending upon the design.

Light signals of the color type were first developed to meet subway and tunnel requirements and are now being extended for use on steam roads. The position-light signal is another development in which a beam of light (made up of a number of hooded electric lights in line) operating through the same angles as a semaphore arm gives the signal indication.

Light signals must be designed with reflectors, hoods and lenses which will prevent light entering



Low Voltage Color Light Signal Used on Chesapeake & Ohio

from the exterior from being reflected out again and thus give a phantom or false indication to an engineman when the lamp is not burning. The candle power varies from 10 to 120, depending upon the efficiency of the reflectors and lenses and the type of lamp used. The lamps are generally hooded to make them more visible as the light serves for a day as well as a night indication.

After deciding on a system of signaling for single tracks signal locations can be marked on a profile of the line. After deciding on the required number of signals between meeting points the distances can then be laid out. An inspection trip should then be made by signal, maintenance-of-way and operating officers and each location studied carefully as it may be necessary to shift it because of physical conditions such as curves, cuts, bridges, fills, grades, etc. In locating a signal it is necessary that an engineman be given as good a view as possible. When signals are located opposite each other the approach from both directions must be considered, for grades or curves may require the favoring of trains from one direction over the other. A signal should not be located at such a point that the stopping of a tonnage train will prevent its again being able to start. The location of passing sidings is one of the most important items affecting track capacity and this must be given careful study in any scheme of signal location.

The section of the R. S. A. specifications for automatic block signals pertaining to field location work stipulates that signals shall be located preferably over or upon the right of and adjoining the track to which they refer. Signal arms on tangent shall be at right angles to the track governed when sufficient approach is on tangent. On curves, signal arms shall be placed at right angles to an imaginary line drawn from the signal to the point where the best view can be obtained by the engineman.

Where signals are located between tracks the center of the signal mast shall be not less than.....ft. from the center of either track. Signals located between tracks on curves, where the track centers are less than.....ft. shall be set off the center line between tracks and toward the center of curves 2½ in. for each 1 in. of super-elevation of the outer rail in the curve.

Bridge masts shall be located on.....chord of bridge.

The base of high ground signals shall be level with the top of the rail unless otherwise specified.

Block Signaling for Maximum Traffic

The conditions which determine the length of a block section and consequently the number of trains that can be run in, a given time are: (1) The speed. (2) The braking power and consequent distance required in which to stop a train running at maximum speed. (3) The grade of the track. (4) The time required for the signals to change from the "stop" position to that indicating "proceed". (5) The length of the train. (6) The position of the interlocking plants, stations and other local conditions which cause an irregular spacing of the signals.

To provide for a maximum train service it must be possible to run trains at the greatest speed local conditions will permit, the blocks being of such length as to allow this speed to be attained with safety. This requires that the engineman be informed at all times as to the track conditions ahead and if it should not be safe to proceed, he must be warned at a point a sufficient distance back of the stopping point so that the train may be brought to a stop before passing it; the greater the train speed the further back the indication to stop or proceed must be given.

The distant signal (in two position signaling) must be placed far enough from the home signal (which governs the entrance to the block) so that the train can be stopped before passing the home signal. Consequently the length of the block is also dependent upon the braking power as well as on speed and grade. The distance between the distant and the home signals for average conditions is the

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length of the shortest block that may be used with safety. As grades assist or retard the speed of trains, they affect the braking power accordingly and the length of the block must be proportional to the grade.

A signal governing the entrance to a block does not begin to clear until the rear of a train has passed out of the block and a few seconds are required for this purpose which is equivalent to lengthening the block the distance the train will run while this signal or this and the distant signal is clearing; the length of a train affects the number that can be run in a given time as it must run its length in addition to the length of the block before the signals can clear for a following train.

The position of interlocking plants, stations and other fixed points affects the space interval which can be maintained between trains, it being necessary to have some blocks shorter than the average length while others are longer which affects the track capacity accordingly.

Requisites of Installation

The requisites of installation perscribed by the American Railway Association are:

(1) Signals of prescribed form, the indications given by not more than three positions: by lights of prescribed color; or by both. (2) The apparatus so constructed that the failure of any part controlling the operation of a signal will cause it to display its most restrictive indication. (3) Signals located preferably over or upon the right of and adjoining the track to which they refer (where a railroad is operated with the current of traffic to the left, the block signals may be placed upon the left). (4) Semaphore arms that govern, displayed to the right or left of the signal mast as seen from an approaching train. (6) Continuous track circuits. (7) Signal connections and operating mechanisms so arranged that a home block signal will display the indications provided in rules 501A, 501AA or 501G after the front of a train shall have passed it. (8) Switches in the main track so connected with the block signals that the home block signal in the direction of approaching trains will display the indications provided in Rules 501A, 501AA or 501G, when the switch is not set for the main track.

Adjuncts

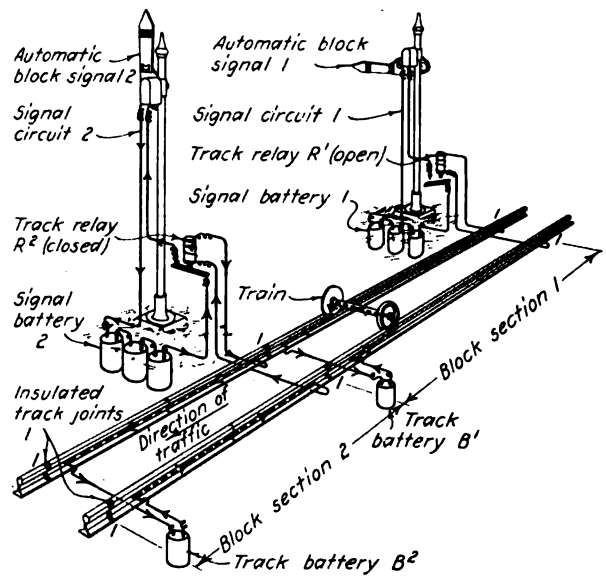
The following may be used:

(A) Distant block signals connected with corresponding home block signals. (J) Take siding indicators. (S) Switch indicators for main track switches. (T) Automatic and train order signals interconnected.

Block signals govern the use of the blocks, but unless otherwise provided, do not supercede the superiority of trains; nor dispense with the use or observance of other signals whenever or wherever they may be required.

A few roads in New England began using wire circuit automatic block signals about 1871 but track capacity was not increased because time interval rules were maintained in full force. The introduction of the track circuit in 1879 gave an impetus to automatic signaling. Signals were first operated by a simple electro-magnet (the enclosed disc signal), the parts being very light. This was followed by the clockwork signal to avoid the disadvantage of the glass enclosure required for the first type. Discs however were generally regarded as inferior to the semaphore and an electro-pneumatic mechanism operating a semaphore arm was the next improvement, this being introduced in 1885. The electric motor signal has made great progress since 1900. There has been no new developments however in motor signals during the past six years. But little use was made of automatic signals on single track lines prior to about 1900.

Signaling began to be required for elevated electric roads about 1900 and as direct current propulsion was used with the rails acting as a return circuit trouble was experienced in the use of the d. c. track circuit schemes employed until, in 1903, the first extensive trials of a. c. track circuits were made in California. The next step in the a. c. track circuit development was the invention of a balanced impedance bond for providing a low resistance path around insulated joints for the d. c. propulsion return current and impeding the flow of a. c. from one section to another, the first installations being made in 1904-5 on the Boston Elevated. In 1906 the Union Pacific installed some a. c. signaling near Council



Simplified Typical Circuit of an Automatic Block Signal System

Bluffs being the first steam road to use this system. Since this date many other roads have made more or less extensive a. c. installations on different parts of their systems.

In 1913 the range of color-light signals was increased to 2,500 ft. for day indications which made them available for use in open country. This development was made a commercial possibility because of the need of a concentrated filament lamp. for the automobile field. The latest development of the color-light signal brought out in 1920 consists of a one unit lamp, hood, lens and reflector with a three-position relay projecting in the focal point of the lens a miniature colored roundel about 1 in. in diameter, the proper aspect displayed depending on the condition of the track. This eliminates two of the three lamp units used by the ordinary color-light signal. The position-light signal was the next improvement and this

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was developed in 1914 and first placed in service on the Pennsylvania in 1915.

The Interstate Commerce Commission Block Signal Report of January 1, 1920, shows a total of 18,486 road miles of single track automatic signaling; 17,389.1 of double track; 552 of three track; 1,532.4 of four track, a total of 37,968.8 miles of road or 60,992.3 miles of track so equipped. Of this mileage, 239.6 miles of road or 384.8 miles of track are equipped with the exposed disc; and 1,279.4 road miles or 2,747.3 track miles with the enclosed disc.

Of the semaphore type of signals in service 599.5 road miles or 1,849.0 track miles are electro-pneumatic; 34,078.8 road miles or 53,164.7 track miles are electric motor; 663.8 road miles or 1,602.0 track miles are electro-gas while under signals not classified (which include light signals) the miles of road so equipped are 1,107.7 or 1,244.5 miles of track. The normal clear system is used on 52,945.9 miles of track while the normal danger scheme is employed on 8,046.4 miles of track. The total number of block sections are 67,266.

Alternating current track circuits are in use on 4,676.5 miles of road or 9,026.0 miles of track while a. c. signal operating circuits are on 4,421.9 miles of road or 8,370.5 miles of track. The miles of road equipped with three-position signals are 20,670.4 or 34,326.4 miles of track. Upper quadrant signals are in use on 20,941.0 miles of road or 34,241.3 miles of track. Overlapped automatic signals are used on 18,272.3 miles of road or 19,471.6 miles of track, while signals electrically lighted protect 7,710.4 miles of road or 13,658.2 miles of track.

See Block System. Also Track Circuit. Also Overlap. Also Signal, Three-Position Signal Colors, Night. Also Signal, Home. Also Signal, Distant.

BLOCK STATION. A place from which block signals are operated. (A. R. A.)

A block station may be a cabin, a two-story tower or a passenger or freight station. Block stations at outlying points frequently consist of one story cabins containing the signal levers, telegraph and telephone instruments and other apparatus while on important lines a two story tower is often employed, the block operator with his necessary apparatus being located in the second story. See Block System, Manual.

BLOCK SYSTEM. A series of consecutive blocks (A. R. A.). A series of consecutive lengths of track of defined limits, the use of which by trains moving on the same track in the same or in opposing directions is governed by block signals located at the entrances to these consecutive lengths of track.

The Interstate Commerce Commission, in defining the term "block system", said that it "shall be taken to mean the methods and rules by means of which the movement of railroad trains (cars or engines) may be regulated in such manner that an interval of space of absolute length may be at all times maintained between the rear end of a train and the forward end of the train next following."

The Block Signal and Train Control Board defined the block system as "any method of maintaining an interval of space between trains moving on a railroad. Primarily the term refers to the spacing of trains moving on the same track in the same direction, but in practice it is used on single track lines, both for this purpose and for the protection from each other of trains moving in opposite directions toward each other."

Two general methods are in use to direct train operation on the railroads of America, the time interval and the space interval. The block system is the space interval method of operation, the space intervals being called blocks. Train operations under this method are directed by (1) time tables, (2) train despatching, (3) train orders and train order signals and (4) the block system. The fixed signals employed in its operation are of three types, train order, interlocking and block and any of the three may be used for spacing trains. These signals may be two or three-position, upper or lower quadrant semaphore, or color or position light signals. They give to a train an exclusive right to the track as far as the next block signal with no restrictions as to the time required, the rate of speed, or the priority of other trains. Although trains are moved under time tables, the block signals placed at known locations enforce an interval of space between trains moving in the same direction regardless of the time interval, thus greatly reducing delays and hazards.

The block system is of two general types; the manual and the automatic, the difference between the two being that the train does not control or but partly controls the signals in the first case, while under the automatic block signal system it completely controls the signals.

The manual block system consists of a series of consecutive blocks, governed by block signals operated manually and entirely on information transmitted from one block office to the next by telegraph, telephone or electric bell code. The operation of this system is dependent entirely upon human agency without any mechanical check.

The controlled manual block system, like the manual, is operated by human agency upon receipt of information transmitted as for the manual system and requires the co-operation of block operators at each end of a block to give a train a clear or a permissive block signal. This system is controlled by continuous track circuits which act as a check upon the action of the block operators. This system may be modified by the use of track circuits at stations only.

The electric train staff system is used in some cases for the movement of trains on single track lines and requires that an engineman have as his authority for the use of the block a staff or small metal rod from a staff machine at a block station which is so locked electrically with the adjacent station machine that only one staff from the two machines can be removed at one time. The staff system may be operated under the absolute or permissive block indications as may be desired by the railroads using this system.

The automatic block system is a power-operated system, the signals of which may be operated by electric, pneumatic or other agency and controlled through the media of track circuits, entirely by the passage of the train through the block sections.

The length of a block section depends upon traffic conditions, the denser the traffic the shorter the block if train delays and reduced track capacity are to be avoided. The length of the block for proper operating efficiency depends upon taking the re-

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quired time interval between trains and making the time lengths of the blocks such that trains can move under clear signals. This means that the space interval may vary, depending upon grade, curvature and other conditions, because a train may cover a greater distance on a descending grade in a given time than it will on a level or ascending grade. In manual block territory the blocks may range in length from a fraction of a mile to 10 or more miles and average about 7 miles which distance may be increased to as high as 30 or more miles at night, if intermediate block stations are maintained during the day only. Under this system the length of the block is not determined so much from the operating requirements as it is from the cost of wages for block operators. Consequently many block offices are located at passenger or freight stations where the station employees also serve as block operators. This results in blocks varying in length and time and thus the time of the trains is limited by the longest block. Under the automatic block system the block lengths can be arranged for the most efficient train operation and maximum track capacity as the wage cost of block operators need not be considered. The number of controlled manual block sections is not as great as is required to handle the maximum traffic because of the high cost of operation as compared with the automatic system which is the lowest of the three.

The selection of the block system to be installed should depend upon the number of trains operated per day. Where traffic is light the manual system (while not furnishing as complete protection) can be used to advantage; as necessity demands this system can be converted to the controlled manual type which affords a higher degree of protection and this in time can be changed over to the automatic block when the traffic conditions warrant.

The block system was first used on double track lines, where a given track is used wholly by trains moving in one direction but it is equally applicable to single track lines used by trains moving in both directions. It was first used in England about 1842 and was first employed in America between Kensington (Philadelphia), Pa., and Trenton, N. J., about 1863. In 1872 when the Pennsylvania Railroad took over this and other lines in New Jersey, the aggregate length of these lines worked by the space interval was 90 miles.

The requisites and adjuncts of installation common to the manual, controlled manual and automatic block systems as prescribed by the Standard Code of the A. R. A. are:

Requisites of Installation

(1) Signals of prescribed form, the indications given by not more than three positions; by lights of prescribed color; or by both.

(2) The apparatus so constructed that the failure of any part controlling the operation of a signal will cause it to display its most restrictive indication.

(3) Signals located preferably over or upon the right (where a railroad is operated with the current of traffic to the left the block signals may be placed upon the left) of and adjoining the track to which they refer (under manual block requisites only). For less than three tracks, signals for trains in each direction may be on the same signal mast.

(4) Semaphore arms that govern, displayed to the right or left of the signal mast as seen from an approaching train.

Adjuncts

The following may be used: (A) Distant block signals interlocked with home block signals; normal indication, "caution" (manual and controlled manual).

Distant block signals connected with corresponding home block signals (automatic block).

(J) Take siding indicators.

Block signal rules governing the operation of signals and trains are given in the Standard Code, A. R. A.

On January 1, 1920, there was a total of 63,915.4 miles of road protected by manual block and 37,968.8 miles of road under automatic block signal protection or a total of 101,884.2. The total miles of road of passenger lines operated as of this date was 194,-594.5. See Signal, Home. Also Signal, Distant. Also Signal, Three-Position. Also Block System, Manual. Also Block System, Controlled Manual. Also Electric Train Staff. Also Block Signal System, Automatic.

BLOCK SYSTEM, CONTROLLED MANUAL.

A series of consecutive blocks governed by block signals, controlled by continuous track circuits, operated manually upon information by telegraph, telephone or other means of communication, and constructed so as to require the co-operation of the block operators at both ends of the block to display a clear or a permissive block signal (A. R. A.).

The principle on which all controlled manual block systems are operated is that before any signal can be displayed to admit a train into a block, the co-operation of two persons, one located at each end of the block, is necessary. This result is obtained by controlling electrically the levers operating the block signals, the electric control being so devised that each block operator must perform certain prescribed manipulations before any signal can be cleared by the block operator at either end of the block to permit a train movement.

Although this system is operated manually, electrical and mechanical means are used to provide more or less complete contol which may be considered as of three classes: (1) A check is provided between operators without the use of track circuits. (2) Short track sections are used at stations for slotting or to control semi-automatic signals and may also be used for clearing signals when a train reaches a station in advance of their location. (3) It may be installed with complete track section control. Greater protection is afforded than given by the manual block as a more complete installation is made. Under (1) the cost of the installation and maintenance is more than for the manual block. Installations under (1) do not protect against broken rails, cars outside clearance points or open switches in the block limits, a mechanical check only being provided in order to make the block operators at each end of a block co-operate in displaying a proceed indication.

Under (2), in addition to the mechanical check provided this system will allow the signal to assume the normal position independent of the block operators by means of a slotted signal. The block operator also receives more specific information as to the position of a train after it has passed his signal, thus helping him in maintainng the proper space or overlap beyond his signal before clearing the block to the rear. This system is more expensive to install and

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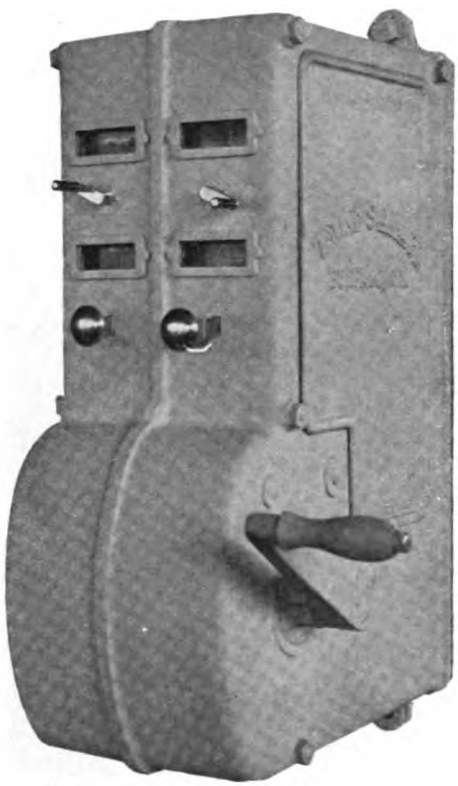
maintain than the manual block or the controlled manual as outlined under (1) and it does not protect against broken rails, open switches or cars outside clearance points except in the territory covered by the short track circuits. Additional expense is incurred when provision is made for clearing a signal when the train reaches a station in advance. This adds additional protection in that it prevents the displaying of a proceed indication before a train is protected by a signal at the station in advance.

The third subdivision above is the most expensive class to install and maintain but it provides the greatest safety in that the block operator has a continuous indication of the condition of the block. The



Station Block Instrument
The General Railway Signal Co.

block occupied; a switch open; a broken rail or a car outside of the clearance point will prevent a proceed indication being given a train.

Distant and advance block signals are often used in controlled manual block signaling. The installation of an advance block signal will permit trains to use the switches between it and the home signal and will help to expedite the movement of trains from block to block when traffic is heavy. Power-operated distant signals may be provided which indicate caution at all times except when the block signals are clear (home and advance block signals); switches set for main track and the section between the distant and block signals is unoccupied. Outlying switches between block stations may be locked and controlled by the block operator in the block station to the rear.

As in the manual system the blocks vary in length and the methods of communication is generally by means of a local block wire which should be used for no other purpose. The communication code used is given under the manual block system.

In controlled manual block operation the block signals govern the use of the blocks and their indications supercede time table superiority and take the place of train orders, unless other provisions are made. These signals do not, however, dispense with the use or the observance of other signals which it may be necessary to use on the railroad at different times or places.

Should the block signal apparatus fail so that the signal cannot be changed from the normal indication the block operator may admit a train to the block by issuing a caution card, a copy of which he should retain. Should communication be interrupted between block stations or the apparatus fail the block operator must set the signals and other apparatus so as to display their most restrictive indication, stop all trains approaching in that direction and be governed by instructions from the properly designated officer. Should he be unable to communicate with this officer, after any train that has been authorized to use the block clears it, he may permit regular trains to pass the stop signal and proceed with caution on their time table authority, expecting to find a train in the block, switch open, a broken rail or a car over the clearance point.

This system may be operated with an absolute block for all movements on the same track; absolute for opposing and permissive for following movements on the same track and absolute block or permissive block for following movements on double track. Permissive movements may be made under a permissive signal indication or on authority of a permissive card issued by the block operator.

The additional requisites and adjuncts of installation as prescribed in the Standard Code of the A. R. A. for the controlled manual block system which were not given under the block system are:

REQUISITES

(5) The normal indication of home block signals—stop.
(6) Continuous track circuits.
(11) The automatic release of block signals to display their most restrictive indication.

ADJUNCTS

(C) Repeaters, audible or visible, to indicate the position of block signals to the signalman operating them.
(E) The locking of switches with block signals.
(H) Lock indicators for main track switches.
(K) Means of communication between block stations and outlying switches.

Block signal rules governing the operation of signals and trains under this system are given in the Standard Code of block signal rules of the A. R. A.

The controlled manual system was first developed in England by W. R. Sykes, where it was known as the "Lock and Block," and a few of these instruments were installed on the New York Central in and near New York City in 1882. J. P. Coleman then devised an improved form of Sykes instrument and the few of these Sykes instruments that were in use in the United States were replaced by the improved type.

The Interstate Commerce Commission's Block Signal Statistics as of January 1, 1920, show that the controlled manual system is in service with no track

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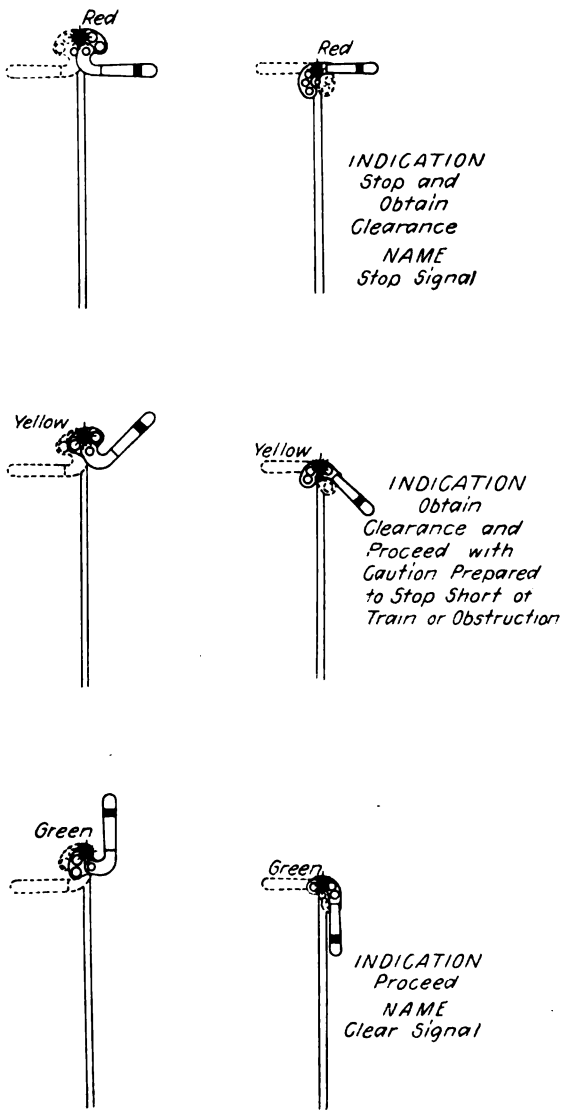
circuits on 1217.7 miles of road while track circuits are used at stations on 196.3 miles of road and that continuous track circuit installations are in use on 129.2 miles of road.

See Block System. Also Block System, Manual. Also Electric Train Staff System. Also Signal, Advance. Also Caution Card. Also Permissive Card. Also Overlap.

BLOCK SYSTEM, MANUAL. A series of consecutive blocks, governed by block signals, operated manually, upon information by telegraph, telephone or other means of communication (A. R. A.). This term is used to distinguish this system from the automatic block system which is controlled automatically by the passage of the trains through the block.

The signals used for spacing trains have their indications given manually by block operators on information conveyed from adjacent block stations by telegraph, telephone or electric bell sounded in accordance with a prescribed code. This system falls under three general classes: manual block, controlled manual block, and staff. The indications may be given by signals working in two or three positions, upper or lower quadrant or both; color or position light signals, and they give a train an exclusive right to the track to the next block signal. The signals may be train order, interlocking or block, as any signals of these types may be used for spacing trains.



Three-Position Upper and Lower Quadrant Manual Block Signal Indications on the Chicago, Rock Island & Pacific

The controlled manual block differs from the simple manual block system by the introducton of electric locking devices attached to the levers (which operate the signals) which requires the simultaneous action of block operators at each end of the block to clear a signal to admit a train into the block. The electric staff system requires that a train have a tangible article, such as a staff or tablet, in place of a signal indication, as authority to proceed into a block.

The simple manual block system is operated by rigid rules but without electrical or mechanical check on the block operators. It is a flexible system, as the number of block offices may be increased or decreased when traffic conditions warrant, thus decreasing or increasing the block lengths; the cost of operation can thus be proportioned to the traffic. This system affords protection against headon and rear end collisions (provided the human element functions properly), but it does not provide protection against open switches, broken rails or cars outside of clearance points. This system is the cheapest to install and to maintain, although the cost of operation is high. Blocks may vary in length from a fraction of a mile to ten or more miles, the usual method of communication in the United States being by telegraph or telephone. Each block station has two home signals, one to govern the movement of trains in each direction (single or double track), the arms for train movements in both directions usually being placed on one mast. Distant signals and advance signals are often installed for the manual and controlled manual systems, all the signals being operated by levers in the block station, standing normally in the stop position, being cleared only on the approach of a train when the block ahead is clear and being restored to the normal ("stop") or to the "caution" position after the train has passed. Each block operator is ordinarily required to keep a record of passing trains on some suitable form for that purpose.

On some roads the manual block system is used with a bell code instead of the telegraph. The following table gives the principal clauses of the code of signals adopted, which cover most of the necessary information to be conveyed:

RINGS	MEANING
1	Acknowledgment of any signal except as noted.
2	Yes.
3	Is block clear? Answer by 2 or 5.
4	Train has entered block.
5	Block not clear.
2-1	No.
2-4	Has train cleared? Answer 4-2 or 5.
3-3	Train is on siding clear of main track.
3-3-3	Train to you broken in two. Answer by repeating 3-3-3 to sender.
4-2	Track has cleared.
9	Stop train. Has no markers.

Under the block signal rules in the Standard Code

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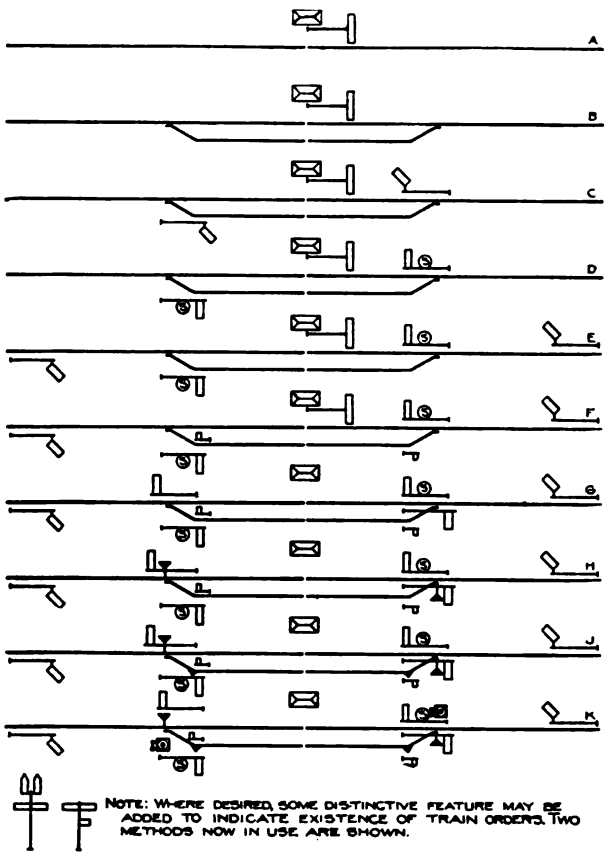
of the A. R. A. the communicating code for the block system is as follows:

RINGS	MEANING
1	Display stop signal.
13	I understand.
17	Display stop signal. Train following.
2	Block clear.
3	Block wanted for train other than passenger.
36	Block wanted for passenger train.
4	Train other than passenger has entered block.
46	Passenger train has entered block.
5	Block is not clear of train other than passenger.
56	Block is not clear of passenger train.
7	Train following.
8	Opening block station. Answer by record of trains in extended block.
9	Closing block station. Answer by 13.

The code for use with the controlled manual block is as above except for the following variations:

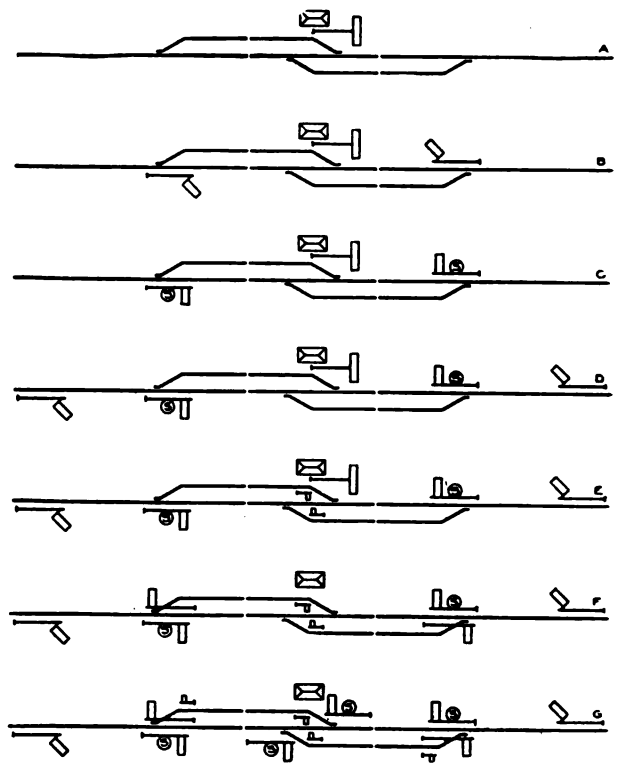
RINGS	MEANING
8	Opening block station. Answer by 2, 5, or 56.
9	Closing block station, followed by 2. If the block is clear, to be answered by 13, followed by 2. If the block is not clear, to be answered by 5 or 56.

When two or more tracks are used in the same direction, block operators in using the code must also specify the track.



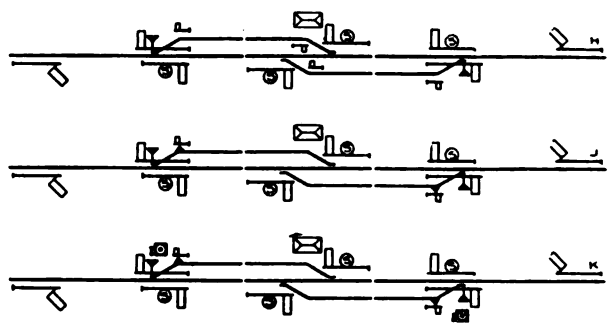
R. S. A. Manual Block Diagrams for Single Siding

In the manual block system the signals govern the use of the blocks only and do not supersede the superiority of trains or dispense with the use or the observance of other signals (unless otherwise provided). A proceed signal indication allows a train to proceed if it has authority by time table or otherwise. When a train proceeds under a caution signal indication or caution card, it should be under control, as the engineman of the train has entered the block knowing another train is also in it ahead and moving in the same direction.



R. S. A. Manual Block Diagrams for Lap Sidings.

Several systems of operation are in use: absolute block for all movements on the same track; absolute for opposing, and permissive for following movements on the same track; absolute block or permissive block for following movements on double track. All movements of snow flangers, push plows, rotary plows, etc., should be made under the absolute block only. In speaking of the operation of the manual block, the Block Signal and Train Control Board said, in its third annual report, that "for safe operation, competent and faithful signalmen are absolutely essential. With first-class men, objectionable methods of operation or maintenance may be tolerated without unduly sacrificing safety; but



R. S. A. Manual Block Diagrams for Lap Sidings, Showing Electric Locking, Etc.

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with incompetent or unreliable men, even the best methods do not insure safety, no refinement in apparatus or system of rules being sufficient to overcome the weakness due to inexperience, slovenly mental habits, poor training, or lack of proper moral qualities."

The additional requisites and adjuncts of installation as prescribed in the Standard Code of the A. R. A. for the manual block system, which were not given under Block System, are:

REQUISITES

(5) The normal indication of home block signals—stop.

ADJUNCTS

(C) Repeaters, audible or visible, to indicate the position of block signals to the signalman operating them.
(D) The automatic release of block signals to display their most restrictive indication.
(E) The locking of switches with block signals.
(F) The track circuits.
(H) Lock indicators for main track switches.
(K) Means of communication between block stations and outlying switches.
(L) The locking of telegraph keys with block signals.

On January 1, 1920, 31,436.3 miles of road under manual block were operated by telegraph; 34,419.4 by telephone, and 947.8 by electric bells, with a total of 11,337 block stations, of which 5,465 were closed part of the time. Permissive signaling is forbidden on 4,234.9 miles of road while it is allowed by despatcher on train order on 24,238.6 miles of road; by rule on 10,851.3 miles; by three-position signals, on 11,751.8 miles; by two-position signals on 2,226.6 miles; by flag or lantern on 468.5 miles; and by caution card on 20,816.5 miles of road. Rear end protection only is given on 10,561.5 miles of road and trains are allowed to stop beyond the signal at stations on 39,250.0 miles of road. The total miles of road equipped with non-automatic block signals (manual, controlled manual and staff) as of the above date is 63,915.4. See Block Signaling, Permissive. Also Block Signaling, Absolute. Also Signal, Advance. Also Block System.

BLOCK SYSTEM, TELEGRAPH. A series of consecutive blocks controlled by block signals operated manually upon information by telegraph (A. R. A.).

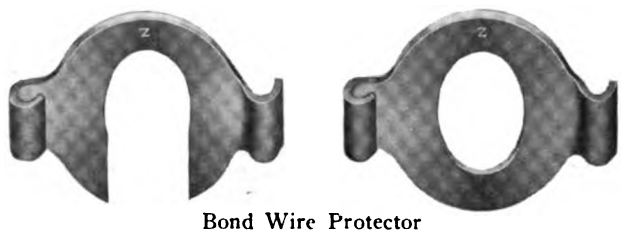
While the A. R. A. has adopted this term, it is not strictly confined to a system in which the telegraph is the medium of communication, as bells with a bell code and telephones are also used. This term is another name for the manual block system. See Block System, Manual. Also Block System, Controlled Manual.

BLOCK SYSTEM, WIRELESS AUTOMATIC. A term sometimes used to define that arrangement of automatic block signals in which line wires for the control of distant signals are eliminated.

The home signal controls the clearing of the distant signal by changing the polarity of the track circuit which extends from the home signal back to its distant signal. When the polarity is changed there is a brief period of time during which no current flows, and to prevent this from opening the signal circuit and wrongfully putting the home signal in the stop position, a slow acting relay or slow releasing slot is used so that before the armature falls the current is restored. See Reluctance.

BOND WIRE. A wire or wires used to connect the adjacent ends of contiguous rails in a track to insure the continuity of that line of rails as an electrical conductor.

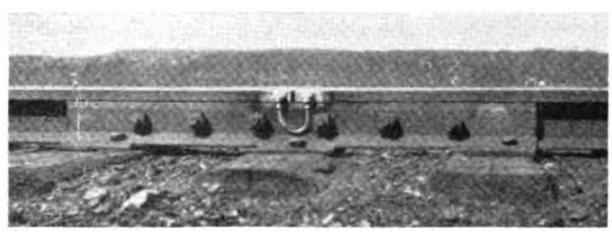
While the joint bars and track bolts in a rail joint help serve as an electrical bond they cannot be depended on. Wires in general use for bonding are of E. B. B. galvanized iron, copper clad steel or copper, and vary in length from 40 to 64 in., depending on the length of the joint bars they have to span. Galvanized iron bond wires are No. 8 B. W. G., while copper clad steel and copper wires are No. 6 A. W. G. They are generally attached to the rails with channel pins. Each rail joint in open territory is generally bonded with two wires so that in case one is broken, the continuity of the track circuit is



Bond Wire Protector
The United Electric Apparatus Co.
(See Page 824)

not broken. Joints in road crossings, on bridges or in similar locations are generally bonded with four wires, thus affording a larger factor of safety and reducing the necessity of removing crossing planks, guard timbers, etc., to replace broken bonds. While copper wires have higher conductivity, they are used mostly for special locations because of the higher cost and the greater liability of theft.

The Railway Signal Association specifies, among other things, that the wire for galvanized E. B. B. iron bonding wires must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections, and must be cut, straightened to length and free from burrs. The galvanizing must consist of a continuous coating of pure zinc of uniform thickness, so applied that it adheres firmly to the iron and presents a smooth surface. The finished wire must be of No. 8 B. W. G., 165 mils in diameter, with a breaking resistance of 975 lb.; an elongation of 15 per cent in 10 in. and a resistance of 12.05 ohms per mile at 68 deg. F. The wire shall not vary more than three mils from the normal diameter.



Welded Bond for Track Circuit
The Ohio Brass Co.

Certain of the specifications for copper clad steel bonding wires require that the wire shall be com-

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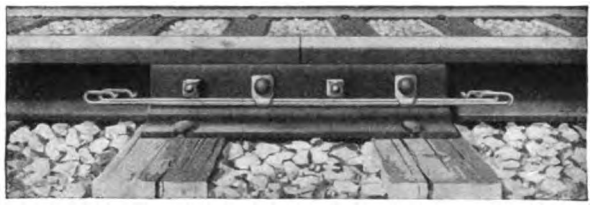
posed of a steel core with a copper coat concentrically placed around and permanently welded to it, the wire to be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections, and the ends to be shear cut and free from burrs. It is further required to be of No. 6 A. W. G.,



Bond Wire Protectors
The P. & M. Co.

162 mils in diameter, with 15 per cent elongation in 10 in. and a conductivity per cent of pure copper at 68 deg. F. of 30 to 50. The wire, when broken by twisting, repeated bending or when heated to a dull red and quenched in water at 32 deg. F., shall show no separation of the copper from the steel. Tests should be made at the mill on the wire before it is cut into length or on samples submitted by the manufacturer and may also be made on the wire upon its arrival at destination. When packed for shipment the wires are to be put up in bundles of 100 or 300 as ordered with the ends well burlapped and each bundle securely fastened in not less than three places.

The present tendency is towards the use of bonds of larger cross sections and welded to the rails. The bonds can be welded to the rails either electrically

Application of Bond Wire Protectors
United Electric Apparatus Co.
(See Page 824)

or with gas. Manganese crossings and special work may be bonded easily by this method, while bonding in road crossings, platforms and paving may be done by disturbing only a small portion of the planking, brick or other paving. See Track Circuit. (See Pages 639 and 824).

BONDING. See Bond Wire.

BRACKET MAST. The upright post mounted on top of the crosspiece of a bracket signal structure which supports the signal arm or arms.

The mast generally consists of a 5-in. pipe 6 ft. long for a one-arm low bracket mast mechanical signal, or a pipe 13 ft. long for a high bracket mast signal. The mast for a two-arm low bracket mast signal is usually 13 ft. long, while that for the high mast signal may be 19 ft. long. The bracket mast for a three-arm signal is usually 19 ft. long. The masts for top-of-mast power signal mechanisms are of the same heights as the mechanical masts. The overall height of power-operated signals with the mechanisms contained in cases, the top of which forms the support for the mast, is generally 13 ft. and 19 ft., the mast itself being shorter than that for mechanical signals by the height of the case, which is about 3½ ft. A long mast is used on some railways for the signal arm governing the high speed tracks, while a shorter one is used to indicate that it governs the freight running or lower speed tracks. The term bracket mast is used to define the upper vertical members of a bracket signal, particularly that one of those members which carries no arm and merely aids in making clear the position and meaning of others, whereas the term mast is employed in the A. R. A. code to define the post (as in a bracket post signal) to which the arm is attached, in distinction from the single post, set in the ground supporting two or more "masts." While the term post is applied to the vertical member of a semaphore signal, because it supports something, and the term pole refers to a slender piece of timber implying inability to support a load. See Bracket Post.

BRACKET POST. A post with a top cross piece which supports two or more bracket signal masts, side by side.

Bracket posts are used on three or four track railway lines; in some cases as one post carrying two bracket signals can be placed on one side of the line to govern two of the tracks, while a ground post or another bracket post can be placed on the opposite side to govern the other one or two tracks,

Bracket Post with Signals and Dummy Mast

thus eliminating the necessity for a signal bridge across the tracks for the support of the signals. The bracket post may consist of 8-in. and 9-in. sections of pipe mounted on a cast steel or cast iron

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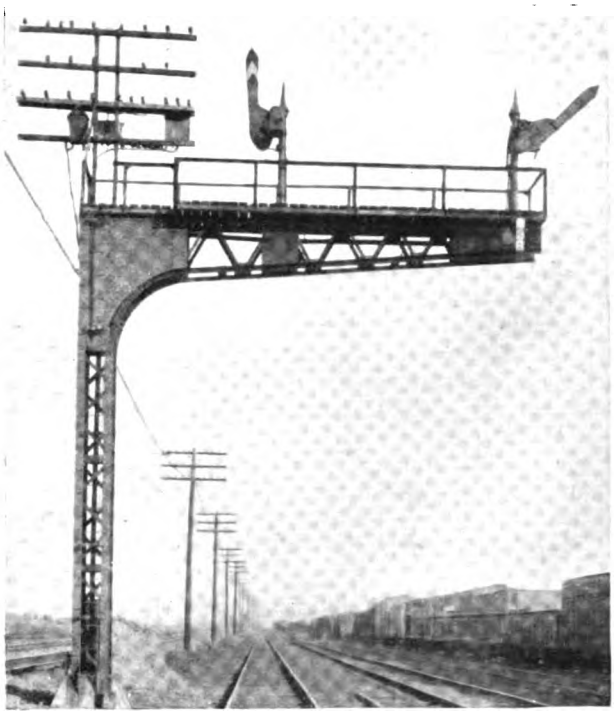
base with a cross tree at the top, or it may consist of a lattice post. The height is usually about 24 ft. from the bottom of the base to the top of the cross

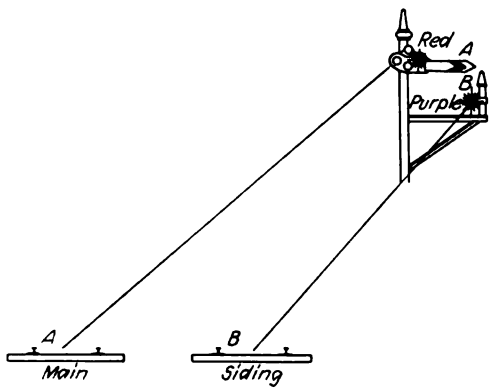


Bracket Post of Cantilever Construction

tree which supports the bracket masts. See Bracket Masts.

BRACKET POST, CANTILEVER. A substitute for a bracket post in which the cantilever signal is a substitute for and conveys the same information as a bracket signal.

The cantilever bracket consists of a doll post of 3, 4 or 5 in. pipe from 3 ft. to 6 ft. in length, mounted



Cantilever Attachment Used on the Chicago, Rock Island & Pacific

on a pipe or angle iron cross tie clamped to the signal mast about 6 ft. below the semaphore bearing, about 4 ft. to 6 ft. away from the post and supported by a pipe or angle iron brace from the post to the end of the cross tie. The doll post usually has a lamp bracket and roundel support in order that night indications may be given by a semaphore lamp. The use of the doll post indicates that the signal arm does not govern the track next to which it may be placed, this post indicating that the track adjacent to the signal is unsignaled at that location. The use of the cantilever bracket posts make it unnecessary to buy the more expensive bracket posts for the purpose of mounting a doll post on one end of the cross piece. Another design of cantilever bracket post consists of the top cross piece in the form of a cantilever extending across the tracks so that a signal post may be mounted directly over the track it governs. See Bracket Post.

BRIDGE MAST. The upright post mounted on a signal bridge as a support for the signal arm or arms. The same type of mast is employed for this purpose as is used on a bracket post. See Bracket Mast.

C

CAB SIGNAL. A signal located in the cab of a locomotive and giving either visual or audible indications.

The term is used to include all arrangements for producing visual or audible indications on moving engines or cars by means of mechanical, electrical or magnetic devices situated on, at the side of or above the roadway and producing effects on moving vehicles. The use of these devices in the United States is confined to certain of the automatic train control systems. See Automatic Train Control.

CAUTION CARD. A form which when filled out properly by a block operator, authorizes a train to enter a block which is not clear.

The Standard Code of the A. R. A. forbids a train to pass a stop signal in manual block territory without receiving a clearance card, caution card, permissive card or a train order authorizing it to do so. The code further requires that "if from any cause, a signalman (block operator) is unable to communicate with the next block station in advance, he must stop all trains approaching in that direction. Should no cause for detaining a train be known, it may then be permitted to proceed with a caution card (Form B), provided — minutes have elapsed since the passage of the last preceding train.

Under the controlled manual block system the standard code states that "Trains must not pass a stop signal without receiving caution card (Form B), permissive card (Form C), or a train order authorizing them to do so. On single track, regular trains receiving caution cards (Form D) may proceed on their time table authority, expecting to find a train in the block, a broken rail or a switch not properly set."

The code further requires that "if from any cause a signalman (block operator) is unable to communicate with the next block station in advance, or if from the failure of the block signal apparatus the block signal cannot be changed from the normal indication, he must set his signal and other apparatus so as to display its most restrictive indi-

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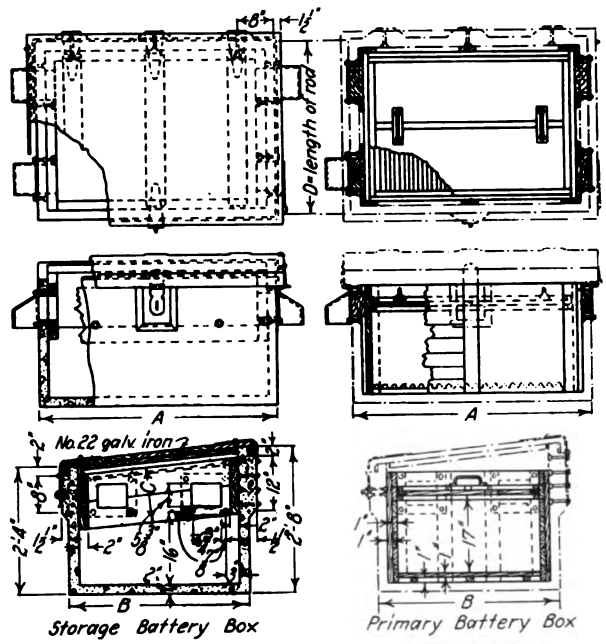
cation, stop all trains approaching in that direction and be governed by directions from the superintendent. If, at the same time, the signalman (block operator) is unable to communicate with the superintendent, he will, after any train (for which "block clear" or "I understand" had been given to the next block station in advance) has cleared the block, permit regular trains to proceed on their time table authority with caution card (Form D) and under stop signal. See Block System, Manual. Also Block System, Controlled Manual.

CELL. A single glass jar, or other container, which, with its contents, forms a source of electricity by means of a chemical reaction between certain elements and the electrolyte surrounding them in the container.

The elements in a cell are commonly spoken of as positive and negative, viewing them in relation to the external circuit. However, looking at the cell from the point of view of its internal working, what is commonly called the positive element is in reality the negative element. For example, in the gravity cell consisting of zinc and copper elements, the copper is commonly called the positive element and the zinc, the negative element, as the current flows from the copper element out through the external circuit and back to the zinc element; but in the cell



A	B	C	D
6'-0"	4'-6"	16"	4'-3"
4'-4"	3'-3"	12"	3'-0"
2'-7"	2'-3"	12"	2'-0"

A	B	D
6'-0"	4'-6"	4'-3"
4'-4"	3'-3"	3'-0"
2'-7"	2'-3"	2'-0"

R. S. A. Battery Boxes for Holding Storage and Primary Cells

itself, the current flows from the zinc to the copper element. The points at which the external circuit joins the elements are called the poles of the cell. Consequently the upper end of the copper element is the positive pole, and that of the zinc, the negative pole. The above distinction should be carefully borne in mind.

Cells are of two general types: primary and secondary, the fundamental difference between the two being that the primary cell develops an electric current by the decomposition of certain materials placed in it, while the secondary cell is capable of producing a current of electricity only after it has had current passed through it from some outside source, as from primary cells or from a direct current generator.

Primary cells are of two kinds: open circuit and closed circuit. An open circuit cell is designed to furnish current only at intervals, as for electric bells, annunciators, telephones, etc., while the closed circuit cell is adapted to furnish current continuously to circuits that are normally closed until it approaches exhaustion; as, for example, to signal and telegraph circuits. The best known open circuit primary cell is the dry cell; others are the sal-ammoniac and the Leclanche, the latter two now being used very little in railroad work. Of the closed circuit type, the gravity cell is perhaps best known, while the Lalande (caustic soda) cell is another example, these types being used extensively in signal service.

The secondary cell may be used either for open or closed circuit work. The two common commercial types are the lead-sulphuric acid cell, consisting of lead plates with an electrolyte of sulphuric acid and the bi-metallic type, the active material for the positive plate of which is nickel-hydrate and for the negative plate, iron oxide with a solution of caustic potash or caustic soda as the electrolyte in which the elements are immersed.

The capacity of a cell for comparative purposes and for estimating the size required for certain work is stated in ampere hours. For example, a cell giving a current of one ampere for 500 hours before it is entirely exhausted is rated as a 500 ampere hour cell at the proper temperature rating. However, with the exception of the Lalande cell, the majority of the primary cells, especially those of the open circuit type, are not generally rated in ampere hours. See Polarization. Also Local Action. Also Battery. Also Depolarization.

CELL, CAUSTIC POTASH. A Lalande cell using caustic potash solution for the electrolyte and having copper oxide for the positive element and metallic zinc for the negative element. With the exception of the electrolyte, it is similar to the caustic soda cell which is now almost universally used. See Cell. Also Cell, Lalande. Also Cell, Caustic Soda.

CELL, CAUSTIC SODA. A Lalande cell using a solution of caustic soda as an electrolyte in which are suspended metallic zinc as one element and copper oxide as the other one. With the exception of the electrolyte this cell is similar to the caustic potash cell. See Cell. Also Cell, Lalande. Also Cell, Caustic Potash.

CELL, DRY. One of the most common forms of primary cells of the open circuit type for intermittent service, using zinc and carbon as the elements with ammonium chloride or sal-ammoniac for the electrolyte. The zinc element forms the container for the cell and a carbon rod is placed in the center of the container, the space between being

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filled with some absorbent material as asbestos, saw dust, blotting paper or mineral wool, which after being tightly packed around the carbon element is soaked with the electrolyte, after which the top is filled with a resinous compound to prevent evaporation.

It is necessary for these cells to have some means of preventing polarization as, with the top sealed, the hydrogen gas formed cannot escape, some depolarization agent must therefore be present to unite with it and prevent it from covering the carbon element. Black oxide of manganese is used for this purpose. The internal resistance varies from 0.1 ohm to 0.7 ohm and when new, the voltage ranges from 1.3 to 1.6 volts. The voltage will gradually fall, even if the cell is not used, because of the drying up of the material. For this reason a cell should not be kept in stock for over one year. A dry cell is convenient because of its portability, it needs no attention until a new one is required. It is used extensively on motor cars, local bell circuits interlocking in towers and other locations, and in telephone work, and for other intermittent service.

Single Dry Cell
The National Carbon Co., Inc.
(See Page 753)

Cells Connected up in Carrying Case
The National Carbon Co., Inc.
(See Page 753)

Single Dry Cell
The French Battery & Carbon Co.

Dry Cells in Case
The French Battery & Carbon Co.

R. S. A. instructions for the testing and maintenance of dry cells require that regular cells be used where the discharge is light and ignitor cells where a heavy prolonged discharge is required; immediately after receipt, regular cells placed on short circuit for 5 sec. at 60 deg. F. must test 15 amperes, and ignitor cells under the same conditions must test 20 amperes; cells are to be used as soon as practicable after receipt to prevent deterioration; kept in a cool place, in an upright position, free from dampness and protected against mechanical injury; wood separators or other suitable insulating material are to be used between cells in service and storage to prevent zinc sides or binding posts from coming in contact; tools or other metal must not be left where they can short circuit the cells; binding posts must be kept free from dirt or other deposits. and where practicable, cells in service must not be exposed to temperatures below 32 deg. F. See Cell.

CELL, LALANDE. A primary cell using a solution of caustic soda, or caustic potash, as an electrolyte in which is suspended metallic zinc as one element, and copper oxide as the other element. This cell is commonly known as the caustic soda, or caustic potash cell. It is used extensively for both open and closed circuit work, although its greatest usefulness is in the latter class, as for the operation of low voltage motor semaphore or light signals (when approach lighting is used in the latter case), and for the various signal and track circuits.

The elements, consisting of zinc and black oxide of copper, are, in general, made in two forms. In one type the zinc element consists of rectangular pieces, suspended parallel to each other from the cover, while the black oxide of copper element is made in the same shape and suspended from the cover between the zinc plates. In the other type the zinc element consists of cylindrical pieces of zinc and cylindrical pieces of copper oxide, the whole suspended from the battery jar cover.

Soda Cell
The National Carbon Co., Inc.
(See Page 753)

The elements are contained in a jar ranging in size from 6⅜ in. by 9⅞ in. for the barrel-shaped, heat-resisting 500 ampere hour glass jar, and 6⅜ in. by 11 in. for the same type jar with straight sides to

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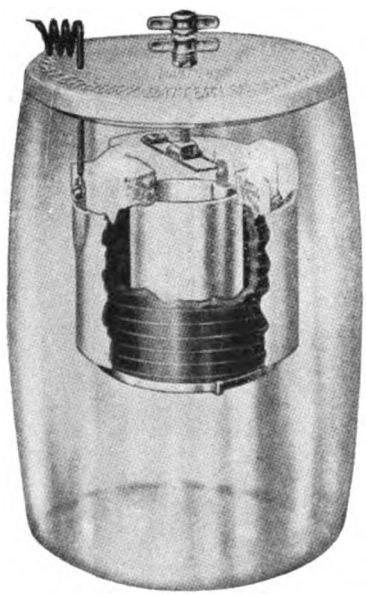
6½ in. by 12⅞ in. for the 1000 ampere hour jar. A similar jar of 6⅜ in. by 8½ in. dimensions is also an R. S. A. standard. The covers may be either of glass or porcelain. Heat-resisting rectilinear glass jars are used to some extent, while a large number of porcelain containers are also in use. The cubical contents of the jar determine the amount of energy the cell will deliver economically and the elements are designed accordingly. The amounts of the elements are so proportioned that when the zinc is practically consumed the copper oxide plate will have been reduced to pure metallic copper.

It is important that the solution be of the proper strength when the cell is first set up if the best results are to be obtained.

Lalande cells may be of high or low internal resistance and of the so-called high or low voltage types. The internal resistance of the cell depends upon the distance between the zinc and the copper oxide elements, the resistance increasing with the distance. In the high internal resistance type this is approximately 0.4 ohm, while in the low internal resistance type it is approximately 0.019 ohm. The voltage of the standard Lalande cell ranges approximately between 0.67 and 0.72 volt per cell at the rated temperature of 70 deg. F., and depending upon the output.

Another type of Lalande cell employs a third element for the purpose of increasing the voltage slightly over that of the standard Lalande cell.

Exhausted elements for all types of this cell should be saved for return to the factory for credit. the copper plates being exposed to air for three or more days (R. S. A.) to eliminate all hazard from spontaneous combustion, as the exhausted copper



Soda Cell
The Waterbury Battery Co.

plates, after being removed from the solution, will reoxidize to a certain extent with the generation of considerable heat. The exhausted elements must be kept dry.

In the maintenance of cells, caustic soda or caustic potash which has been damaged by exposure to air or dampness must not be used. When setting up cells the caustic soda or caustic potash should be added to the water gradually, stirring with a clean wood stick until thoroughly dissolved and only the exact amount of soda or potash furnished per cell

Soda Cell
Thomas A. Edison, Incorporated

should be used. Care must be exercised in mixing and handling the solution, as it will burn the skin or clothing, and if it is splashed on either accidentally it should be washed off immediately. After the assembled element is inserted in the solution the exact amount and kind of oil furnished with the cell must be added to the top of the solution, unless the oil is self-contained in the element. When the elements are placed in the solution while hot, the cells should be connected at once and when it is not practicable to operate apparatus to cause immediate discharge, the battery must be discharged at a rate not to exceed 3 amperes for 10 minutes. The cell should be inspected when the solution cools, water should be added to bring the top of the oil ⅝ in. from the top of the jar and the solution again stirred. See Cell. Also Polarization. See Cell, Caustic Soda. See Cell, Caustic Potash.

CELL, GRAVITY. A common form of primary cell of the closed-circuit type, using zinc and copper as the elements and solutions of zinc sulphate and copper sulphate as the electrolyte.

The zinc, in the form of an open wheel or crowfoot and weighing approximately four pounds, is suspended in the top of the jar and sheet copper in the form of leaves rests on the bottom of the jar, and approximately 3½ lb. of crystals of blue vitriol (copper sulphate), which acts as a depolarizer, are placed around the copper. On the addition of water, a solution of copper sulphate is formed from which a solution of zinc sulphate results by chemical action, following the short circuiting of the cell for a period of 48 hours. The clear blue copper sulphate solution, being heavier than the zinc sulphate solution, collects at the bottom of the cell around the

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copper element, while the zinc sulphate solution remains at the top surrounding the zinc element, hence the name gravity cell.

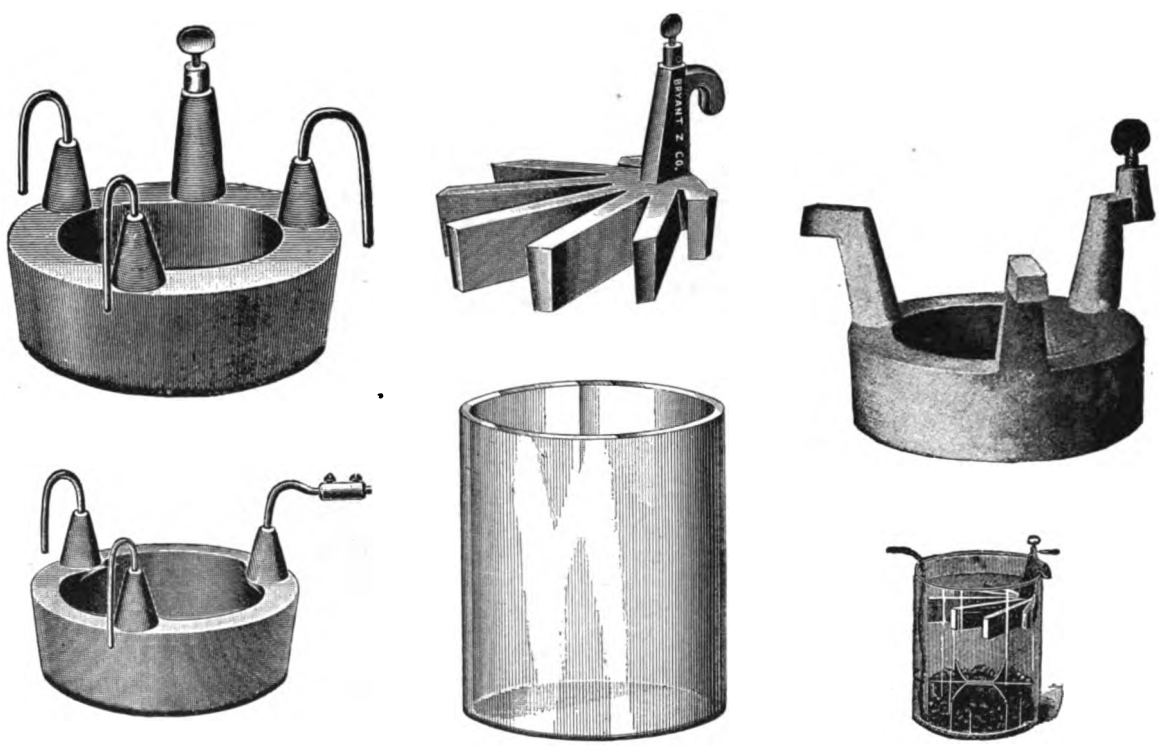
Where it is impractical to wait 48 hours for a gravity cell to reach a proper working condition, as in signal work, it is the practice to add about 1 pint of the clear zinc sulphate solution from an old cell to the cell on setting it up after cleaning or, when this solution is not available, a small amount of sulphuric acid may be used which sets up a chemical action, producing zinc sulphate. On closing the circuit the copper sulphate is decomposed, depositing metallic copper on the upper plate, and liberating sulphuric acid which attacks the zinc plate, yielding zinc sulphate. In order to prevent excessive local action in the cell, which can be caused by commercial zinc containing foreign particles, the zinc is amalgamated, the action of the amalgam bringing the pure zinc to the surface and leaving the foreign particles behind.

The condition of the cell can best be determined by observing the position of the line of demarkation between the two electrolytes, the cell being in the most efficient condition when this line is approximately half way between the copper and zinc elements. When the zinc sulphate solution extends down near the copper, a part of it should be drawn off and more copper sulphate solution added, this being done through a tube so as not to disturb the equilibrium of the liquids. The zinc element must be renewed in track circuit cells when it has been reduced to 1¼ lb., and should be removed from cells in other circuits when it weighs approximately ¾ lb., while the copper element should be replaced when it weighs over 2 lb. or is liable to bind in the jar when it is next cleaned.

The ordinary gravity cell is of the high internal resistance type, having approximately 3 ohms resistance and a voltage of about 0.8 or 0.9 volt, and remains active for long periods on closed circuits without appreciable polarization. The voltage and current output of this cell are dependent on the condition of the electrolyte, the elements and the distance between the elements. As the distance is decreased the internal resistance is lowered and the current output increases up to a certain point.

The gravity cells used in signal work consist of a round glass jar 6 in. by 8 in. inside dimensions, generally of machine-moulded glass with ¼-in. walls containing a 4-lb. round zinc having an outside diameter of 5 in., an inside diameter of 3⅜ in., and being 1⅛ in. high, and a two or three leaf copper element 2¼ in. high with a 5-in. spread, having a 15-in. No. 14 B. & S. gage soft drawn copper lead wire with a 3/64-in. wall of rubber insulation to prevent the electrolyte from coming in contact with it.

The zincs are made of virgin spelter cast at a low temperature and thoroughly amalgamated with mercury, the R. S. A. specifications for the chemical composition of the zincs requiring not less than 2.00 per cent of mercury; not more than 0.10 per cent of iron; not more than 0.50 per cent of lead; not more than 0.40 per cent of other impurities; and not less than 97 per cent of zinc. Likewise it is specified that the copper must be of two or three leaves of No. 30 B. & S. gage hard rolled bright copper not less than 98 per cent pure. These specifications further require that the copper sulphate



Types of Zincs Used in the Gravity Cell with Glass Jar and All Assembled

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crystals shall be of such size that not more than 5 per cent by weight shall pass through a sieve of ¼ in. mesh; not more than 45 per cent by weight through a sieve of ¾ in. mesh, and all shall pass through a 1¼ in. mesh sieve. The crystallized copper sulphate shall contain not less than 98½ per cent pure crystallized copper sulphate; not more than ¾ of 1 per cent of sulphate of iron; not more than ¼ of 1 per cent of sulphuric acid, and not more than ½ of 1 per cent of other impurities. R. S. A. instructions for maintenance require that the bottom of the zinc shall be about 2¾ in. above the top of the copper; clean, soft or distilled water shall be used in the jar to within one inch of the top of the zinc, and about 1 pint of zinc sulphate shall be poured carefully on top of the zinc, sufficient to cover it about ½ in.; and that the gravity must not be below 15 deg. on a Baume hydrometer before using a new or a cleaned cell. On cleaning, the zinc should be removed, using care to prevent any dirt accumulations from dropping back. The zinc should be thoroughly cleaned with a scraper, brush and water. The solution must not be poured where it will run outside the right-of-way into running water or on metal, or into trunking or on a grass line; unused copper sulphate must be washed and cleaned and the metallic copper separated from it; zincs must be cleaned at least once a month; the specific gravity must never be allowed to get above 35 deg. on the hydrometer and should be kept between 15 deg. and 25 deg. The gravity can be reduced by removing part of the zinc sulphate solution and adding water.

The gravity battery was used almost universally on track circuits and for similar work, until the cost of renewals became almost prohibitive during the war, at which time the Lalande cell replaced the gravity cell for track circuit work to a great extent. The gravity cell is used by some railway companies for keeping storage batteries charged at signal locations. See Cell. Also Local Action. Also Polarization. Also Cell, Primary.

CELL, PRIMARY. A device for converting chemical energy directly into electrical energy.

A large number of such cells employing different elements and electrolytes are in use. The chemical action is electro-chemical, the electroylte and one or both of the elements being decomposed by the passage of the current. In the cell the current flows from the metal most acted on to the metal least acted on, while in the outside circuit the direction of flow is opposite. The most usual combinations of elements are (1) zinc and carbon, and (2) zinc and copper. See Cell. Also Cell, Secondary.

CELL, SECONDARY. Any combination of two metals or metalloids immersed in an electrolyte which in itself will not produce electricity without first having its elements decomposed by the passage of electric current through it.

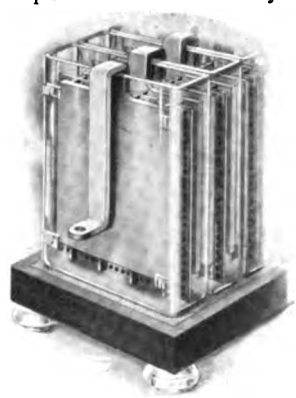
When the cell gives out current, part of the electrolyte combines with the elements, and when the combination approaches the point of exhaustion the cell may be restored to the fully charged state by passing a current of electricity through it from some outside source, as from a direct current generator, which causes a reversal of the chemical action. The two common commercial forms of this type of cell are (1) lead peroxide and lead plates as the elements in a solution of dilute sulphuric acid as the electrolyte, and (2) plates having nickel-hydrate and iron-oxide as the active material in a solution of caustic soda or caustic potash as an electrolyte. See Cell. Also Cell, Storage. Also Cell, Primary.

CELL, STORAGE. A common form of secondary cell, using lead plates as the elements in dilute sulphuric acid as an electrolyte or using a positive plate of nickel-hydrate and a negative plate of iron oxide in a solution of caustic potash or caustic soda as the electrolyte. Stationary and portable types of cells are employed.

Lead Type Cell

The lead type storage cell commonly used in signal service consists of positive and negative plates suspended by lugs from the top of the jar and immersed in an electrolyte of dilute sulphuric acid having a specific gravity of approximately 1.200 when the cell is fully charged. The positive element has lead peroxide as its active material while that for the negative element is metallic lead in sponge form. The positive plates have a dark reddish brown or chocolate color when fully charged and in good condition, while the negative plates are grey or slate colored. The chemical reactions are highly involved.

A fully-charged cell on open circuit has a voltage of approximately 2.1 volts which, when placed on discharge, becomes approximately 2 volts, reaching about 1.8 volts when completely discharged. The voltage varies with the density of the electrolyte and to a certain extent with the temperature. This cell has practically a negligible internal resistance, and must not be short-circuited. Its capacity depends upon the number and size of the plates, their area exposed to the electrolyte and the quantity of active material on them. The plates are of two types, the formed or Plante, and the pasted or Faure. The Plante type is made by means of chemical or electro-chemical corrosion of the lead plate in an electrolyte of sulphuric acid and water, while the pasted type is formed by applying a paste made of lead oxides to a grid. There are many combinations and modifications of these two types. Plates have a capacity of from 40 to 60 ampere hours per sq. ft. of positive plate surface, taking an 8-hr. rate of discharge, and a temperature of 60 deg. F. as standard. Storage cell capacity is rated in ampere-hours. Thus a 120-ampere-hour cell would give a continuous discharge of 15 amperes for 8 hours. Theoretically this cell should give 30 amperes for 4 hours, etc., but this is not actually the case, as an increase of the discharge rate decreases the ampere-hour capacity. There is always one more negative



Plante Type Storage Cell
The Willard Storage Battery Co.

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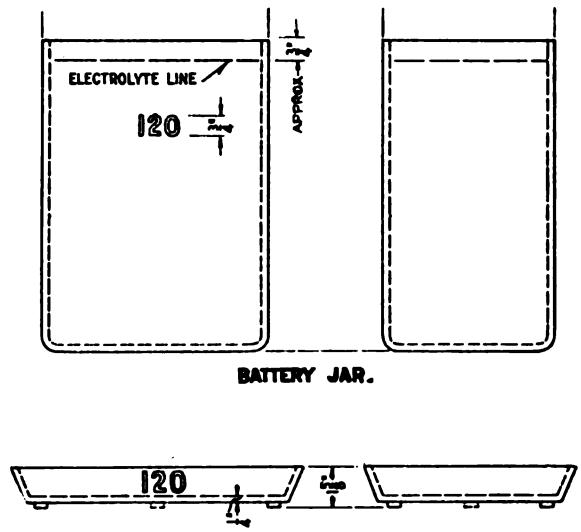
plate than positive plate, so that on assembly the positive plates, which are connected together, are placed between the negative plates, which are likewise connected. As the space between the plates is small, separators made of hard rubber or of wood are placed between them to prevent contact, which would short-circuit the cell.

The R. S. A. complete storage cell consists of the positive and the negative elements in an electrolyte of dilute sulphuric acid, wood separators, a glass jar, a glass sand tray, glass cover and glass hold downs. The plates for 40-ampere-hour stationary storage cells are 6 in. by 6 in., with a thickness of 3/8 in. for the positive and 1/4 in. for the negative, there being two positive and three negative plates per cell. The plates for 80-ampere-hour cells are 7 3/4 in. by 7 3/4 in., the positive being 7/16 in. thick and the negative 17/64 in., there being 2 positive and 3 negative plates per cell. The 120 and 200-ampere-hour cells have plates the same size, but there are 3 positive and 4 negative plates for the 120 a. h. cell and 5 positive and 6 negative plates for the 200 a. h. cells. The 320 and 400 a. h. cells have plates 10 1/2 in. by 10 3/4 in., the positives being 7/16 in. thick and the negatives 5/16 in. thick. Four positive and 5 negative plates are used for the 320 a. h. cell while 5 positive and 6 negative plates are used for the 400 a. h. cell. The minimum weight of the positive plates is 17 lb. per sq. ft., and for the negatives 11 lb. per sq. ft. The plates forming each element are fastened in multiple to lead straps and spaced 1 1/8 in. apart.

Cell with Glass Sand Tray
The United States Light & Heat Corporation

The wood separators are made of veneer 1/16 in. thick and are 6 3/8 in. by 6 3/8 in. for the 40 a. h. plate; 8 1/4 in. by 8 1/4 in. for the 80, 120 and 200 a. h. plates, and 11 7/8 in. by 11 7/8 in. for the 320 and 400 a. h. plates. The separators are mounted on end and intermediate wood posts of 3/8 in. by 5/8 in., 3/4 in. and 1 in.; and 3/8 in. by 3/8 in., respectively, at the proper height to prevent contact of any parts of the plates. Four separators are used for the 40 and 80 a. h. cells; 6 for the 120, 10 for the 200 and 400, and 8 for the 320 a. h. cell.

The battery jars, sand trays, cell covers and hold downs are of clear, uniform glass, free from blow holes, the various dimensions being as follows:

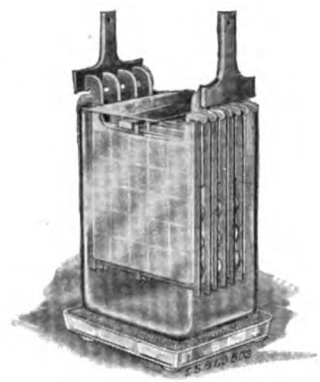


R. S. A. Storage Battery Jar with Sand Tray

The jars are set on trays filled with sand to insulate them from each other as, due to different causes, a moist deposit of sulphuric acid may collect on the outside of the jar which, on coming in contact with the shelf holding the cell and the moisture from the adjacent jar, would cause a loss of electricity. The sand also forms an even, uniform bedding and support for the glass jar.

The cell covers are of sheet glass corrugated on one side parallel to the width and are from 3/16 to 1/4 in. thick, while the hold-downs are of two types, type A being a rectangular piece of glass 3/8 in. thick and 1 1/2 in. wide, while type B is a round glass rod 3/8 in. in diameter. The other dimensions for the two types are shown in the table below The hold-downs are laid across the top of the plates to keep the wood separators in place.

R. S. A. specifications require that the electrolyte shall be free from impurities within limits as specified, this to be determined on acid of 1.832 specific gravity. The allowable percentages of impurities are: Platinum, acetic acid.



Stationary Type Chloride Accumulator
The Electric Storage Battery Co.

A. H. Capacity	Battery Jars Inches			Sand Trays Inches		Cell Covers Inches		Hold Downs No. per Cell			Lbs. per Cell
	Length	Width	Height	Length	Width	Length	Width	Length	Type A	B	Electrolytes*
40	7 3/8	4 1/4	11	9 1/8	6 1/2	6 1/2	4	3 7/8	1	2	9.2
80	9 1/4	5 1/2	12 3/4	11	7 1/4	7 1/4	5 1/4	3 7/8	1	2	15.6
120	9 1/4	7	12 1/4	11	8 3/4	8 3/4	5 3/4	5 1/2	1	2	21.1
200	9 1/4	10 5/8	12 3/4	11	12 3/8	12 3/8	5 3/4	9	1	2	29.6
320	12 3/8	*7 3/8	17	14 1/8	9 1/8	9 1/8	8 1/2	6 1/2	2	2	51.0
400	12 3/8	10 5/8	17	14 1/8	12 3/8	12 3/8	8 1/2	9	2	2	59.0

*Electrolyte of 1.210 specific gravity.

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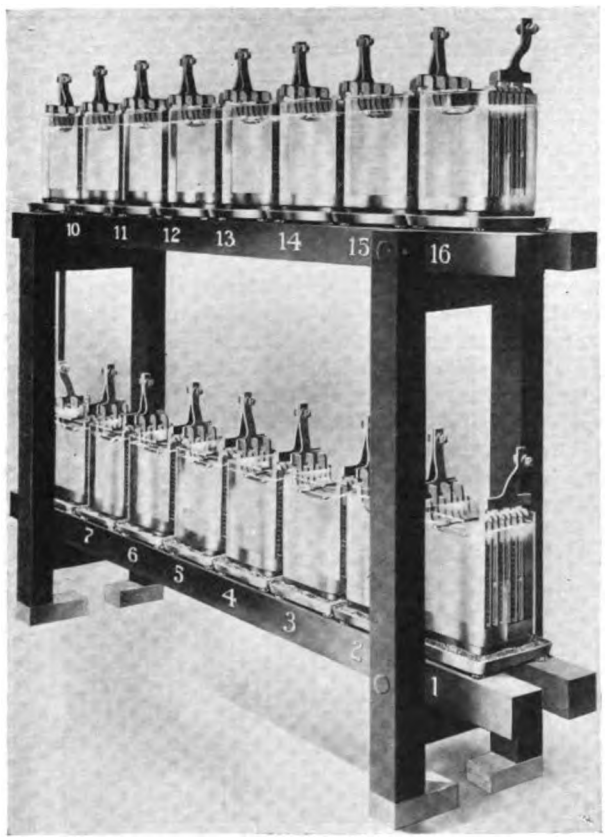
tartaric acid and organic matter, none; iron, 0.004; chlorine, nitrogen in any form as ammonia, nitric acid, etc., mercury, citrates, 0.001; copper, 0.0016; arsenic, sulphur in any form except free sulphuric acid, tin, selenium, manganese, thallium, calcium, sodium, potassium, aluminum, silicon, less than 0.001; zinc, 0.01; antimony, 0.04. The electrolyte is shipped in glass carboys containing from 110 lb. to 130 lb. each.

When storage cells are charged by primary cells a sufficient number should be used to keep the storage cells at an approximately constant state of charge, so that the voltage per cell will average between 2.08 volts and 2.12 volts. A higher average indicates too much charge, which is also indicated by the cell giving off constantly a slight amount of hydrogen gas. At 70 deg. F. the specific gravity of a fully charged cell should be between 1.205 and 1.215, with the electrolyte ½ in. above the plates. Should the voltage drop below 1.95 volts per cell and the specific gravity drop 10 to 15 points below normal, the cause should be investigated. If it becomes necessary to remove or loosen sediment, a wood strip or hard rubber should be used. Metal must not be used for this purpose. Some indications of trouble in a cell are: falling off in specific gravity or voltage; lack of or slower gassing; or plates which are markedly lighter or darker in color than in adjoining cells. If the plates cannot be transferred from a broken jar to a new jar and must remain out of service for some time, the positives should be kept dry and the negatives completely immersed in water. Some of the common troubles affecting cells are: loss of voltage and capacity; shedding of active material; and distortion, fracture and corrosion of electrodes. Practically all of these troubles except the last are caused from over-discharge.



Storage Battery Mounted on Rack—Typical Layout for Battery Room at a Power Interlocking Plant

Exide Portable Battery with Covers Removed
The Electric Storage Battery Co.

Plates must be kept covered ½ in. above the tops with electrolyte; only chemically pure water, preferably distilled, must be used to replace evaporation; electrolyte should not be added except under certain conditions; sediment should never be allowed to reach the bottoms of the plates, but should be removed when the clearance decreases to ½ in.; when cells are located in a room, it should be ventilated freely, especially when charging; an exposed flame should never be brought near the cells when they are being charged; metals or impurities should not be allowed to get in the cells; if this happens, the plates should be removed and washed and the electrolyte renewed.

As a general rule a storage battery should be charged at its normal charging rate, after being about one-third discharged. Once every two weeks the regular charge should be prolonged until 15 min. readings of the specific gravity and of the voltage of the pilot cell, taken from the time the cells commence to gas, show no rise on five successive readings. If the above is not practicable, the overcharge may be given every sixth charge, provided the

Edison Alkaline Storage Battery Assembled in Portable Case
The Edison Storage Battery Co.

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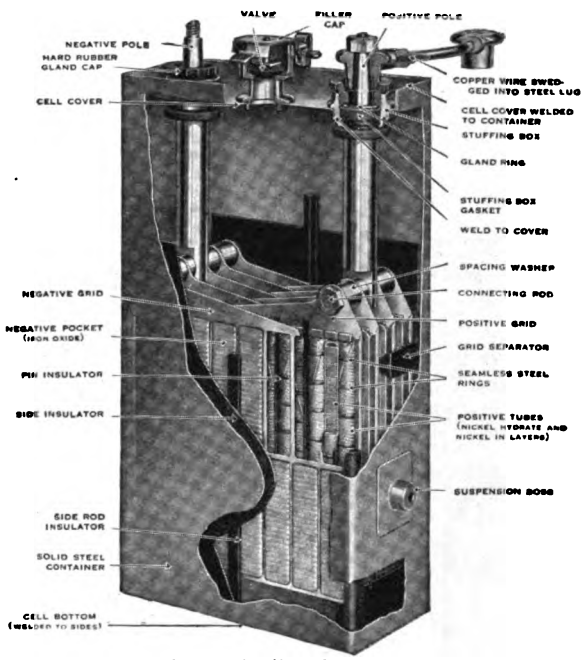
battery receives an overcharge at least once a month. In this case the regular charge should be prolonged until half hour readings of specific gravity and voltage taken from the time the cell begins to gas, show no rise on seven successive readings. On discharge, the specific gravity should never fall more than about 30 points below the preceding overcharge maximum. As a rule it should not fall more than 20 points. The voltage should never drop below 1.85 volts when discharging at the normal rate, while if the discharge rate is less than normal, the voltage should not be allowed to go so low. A battery should never be allowed to stand in a completely discharged condition.

Directions for the installation of and instructions for the operation of the lead type portable storage battery are in general somewhat similar to that above. Variations occur because of the different



Edison Alkaline Storage Cell
The Edison Storage Battery Co.

conditions prevailing and the types of construction employed.

Lead cells at interlocking plants should be isolated in a room, well ventilated and lighted, and as dry as possible, because the acid fumes given off during charge are corrosive. For this reason the room should have no exposed metal (except lead which the fumes do not affect) unless it is protected by at least two coats of acid proof paint. A battery room floor should provide proper drainage and should be preferably of vitrified brick joined with petroleum asphaltum. The cells should be supported on a wood frame or rack and in such a position as to be readily accessible for inspection and cleaning. After setting the cells up, the initial charge should be continued for 10 hours after the maximum voltage and gravity have been reached, which should require from 40 to 60 hours at the normal rate.

The Nickel-Iron Alkaline Cell

Cells designated as types A and B are used in signal work, type A being about twice the size of type B. The positive and negative plates are arranged alternately with hard rubber separators between and are made of steel grids upon which the solution of caustic soda or caustic potash has no effect. The active materials are nickel hydrate for the positive plate (considered externally), and iron oxide for the negative plates. The nickel hydrate is enclosed in perforated steel tubes which are arranged in a row of columns for each plate and secured to a grid. The iron oxide of the negative plate is held in perforated steel pockets, also firmly fastened to the grid.

On charging, the nickel hydrate is changed to nickel dioxide and the iron oxide is changed to metallic iron. As the cell discharges, the metallic iron again becomes oxidized and the nickel dioxide is converted into another combination of nickel and oxygen. Unlike the lead type cell, the electrolyte furnishes no indication of the amount of charge, as the gravity remains practically constant at all times. The specific gravity of potassium hydrate electrolyte is 1.250 and of sodium hydrate 1.190 before immersing the plates, while the normal specific gravity of the former in the cell is about 1.200 and of the latter, 1.160.

The voltage of each cell on a normal charge will vary from about 1.5 volts at the beginning to 1.80 or 1.85 volts at the end. When a voltage of about 1.80 is reached and maintained constantly for 30 min. with the normal current flowing, the cell is fully charged. The cell has an average voltage of 1.20 at the 5-hr. discharge rate, 1.24 at the 8-hr. rate and correspondingly higher at lower rates up to 1.40 volts. Unlike the lead type cell, no damage can be done to plates by discharging to exhaustion or zero voltage.

These cells can be charged at the normal rates for 7 hours or higher than normal at the beginning and lower than normal at the end so that the average is normal. In the latter method an average per cell of approximately 1.75 volts should be maintained throughout the charge. Low rates may be used in charging when the discharge rate is not less than 1/10 the rated capacity.

When potassium hydrate electrolyte is used and the gravity falls to 1.160 with the cell fully charged it should be renewed; when sodium hydrate electrolyte is used, the cell should be renewed when the gravity falls to 1.130 but the cell in each case should be entirely discharged before renewing the old solution. The electrolyte should be tested at least once a year for specific gravity and only when the battery is fully charged. These cells for signal work are rated in 40, 80, 120, 225, 300, and 450 ampere hour capacities.

Storage cells are used at electric and other power interlocking plants, for operating drawbridges, power operated signals, track circuits, signal lighting, relays, indicators, electric bells, electric locks, etc. See Cell.

CHANNEL PIN. A tapered metal plug in the shape of a truncated cone which is used to fasten a bond wire to the end of a rail in a track circuit. This plug has a longitudinal slot of radius equal to that of the bond wire so that the two, when inserted and driven in a hole in the rail, will be wedged firmly together and against the rail, thus forming a good mechanical contact between the wire and the rail to carry the electric current around rail joints and thus

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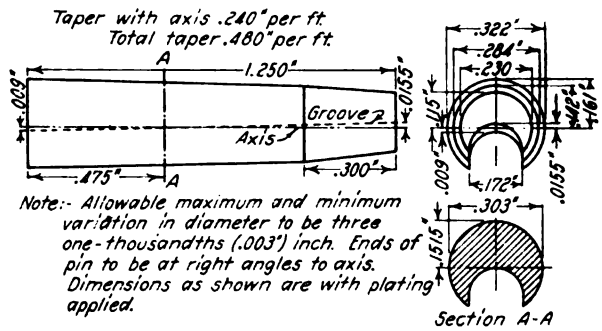
make the track circuit continuous. The bond wires commonly used have a diameter of 0.165 in., the wire and pin being driven into a 9/32 in. hole.

The channel pins are made of steel or iron containing not less than 0.15 per cent nor more than 0.20 per cent of combined carbon and are 1¼ in. long with a



R. S. A. Channel Pin

diameter of 0.322 in. at one end, tapering to a diameter of 0.230 in. at the end to be inserted in the rail. The groove has a diameter of 0.172 in. A duplex channel pin is also used to a limited extent. This pin has two parallel longitudinal grooves, permitting two wires to be fastened to the rail with the one pin.

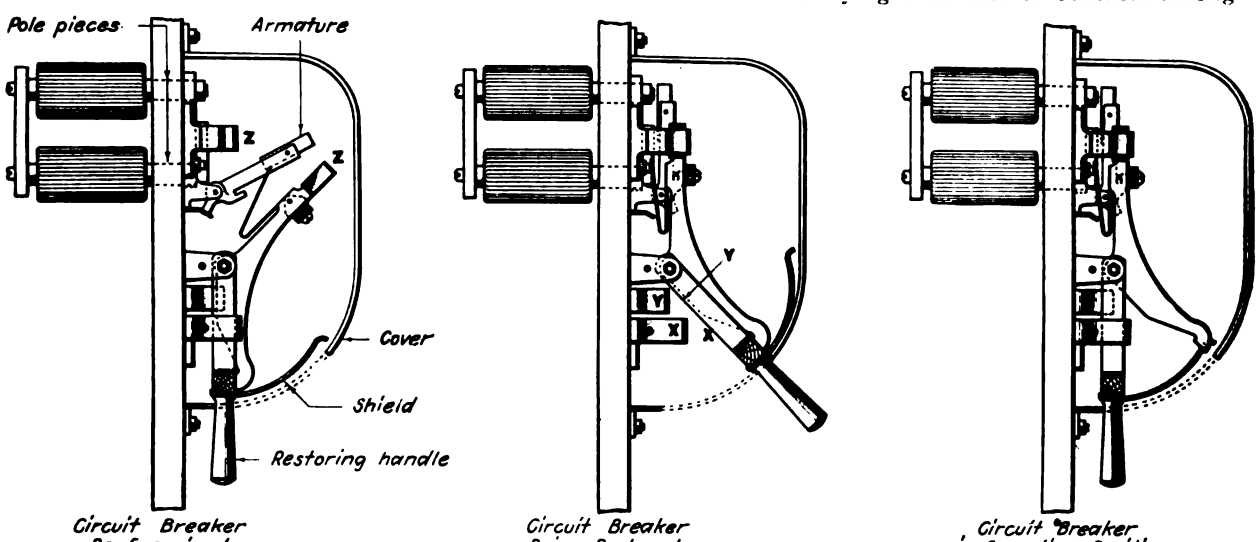
The specifications of the R. S. A. require that the pins shall withstand being driven entirely through a hole 9/32 in. in diameter, drilled in a piece of steel plate 9/16 in. thick without showing a flaw or crack of any kind. In addition the pins, after being driven in half their length, shall stand bending at the large end 90 deg. flat on the plate sidewise to the groove without cracking or showing a fracture of any kind.

The pins may be either tin or copper plated. The tin plating is required to be done either by the hot or the electric process in a manner similar to galvanizing; it shall be heavy and well done, even in thickness throughout, smooth and free from lumps. The coating shall be not less than 98 per cent pure tin. To test channel pins for tin plating, the specifications require that they must be thoroughly cleaned with gasoline or varnish remover and then with soap and water; after being rinsed they are immersed in a solution of hydrochloric acid for one minute and, without wiping, dipped into a ferro-cyanide solution. The pins should then be washed in clear water and the above operation repeated. Pins plated in a satisfactory manner shall stand four immersions of one minute each in the hydrochloric acid solution without showing a blue precipitate or discoloration in the ferro-cyanide solution, which discoloration indicates that the tin coating has been dissolved. The hydrochloric acid solution is required to have a specific gravity of 1.10, made by diluting hydrochloric acid having a specific gravity of 1.20 with distilled water, while the potassium ferro-cyanide solution is made by dissolving 5 grams of the salt in 1,000 cubic centimeters of distilled water.

The copper plated pins are required to be copper plated by the cyanide process, heavily electro-plating the pins with a uniform, homogeneous coating of copper, which shall average at least 0.3 lb. of copper per 1000 pins.

CIRCUIT BREAKER, AUTOMATIC. A device for opening an electric circuit automatically when the current passing through it becomes excessive or is reversed.

A circuit breaker, as used in direct current electric interlocking work, consists of an electro-magnet and an armature carrying a contact or contacts through which pass the circuits to be protected. When the electro-magnet is energized, the armature is held in place close to the pole pieces and the contacts are closed, but any interruption to the circuit through the electro-magnet will de-energize it, allowing the armature to fall away, thus opening the circuit or circuits through the armature contacts. After the trouble has been removed it is necessary to reset the armature by hand. Circuit breakers for signal work



Parts similary lettered make contact with each other
Sectional View of Operating Switch Board Circuit Breaker.
The General Railway Signal Co.

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are used on the power and operating boards at interlocking plants and on power boards for other classes of work. A no-voltage, reverse-current circuit breaker is used on interlocking power boards and is placed in the charging circuit between the battery and the generator so that if the generator voltage should fall below the battery voltage it will open the circuit. Circuit breakers used for cross protection purposes on operating boards have the feeder wires from the battery to the interlocking system broken through the armature contacts, so that when the circuit of which the retaining magnet is a part is interrupted, energy is cut off from the interlocking system or from a part of it if the plant is sectionalized, in which case a circuit breaker is used for each section.

CIRCUIT CONTROLLER. A device used for opening and closing circuits and connected to various signal appliances. It is also sometimes an integral part of the switch operating mechanism or signal itself. See Switch Box (also called Switch Instruments).

CLEARANCE CARD. A form which, when filled out by a signalman (block operator) authorizes a train to enter a block when the signal cannot be cleared.

The form of the card and the rules pertaining to its use in the manual and controlled manual block system are designated by the A. R. A. in the Standard Code. The form is printed on white paper and the rules governing its use state that if, from the failure of block signal apparatus, the block signal cannot be changed from the normal indication, a signalman (block operator) having information from the signalman (block operator) at the next block station in advance that the block is clear, may admit a train to the block by the use of clearance card (Form A). Trains must not pass a stop signal without receiving this clearance card, a caution card (Form B), a permissive card (Form C) or a train order authorizing it to do so. See Block System, Manual.

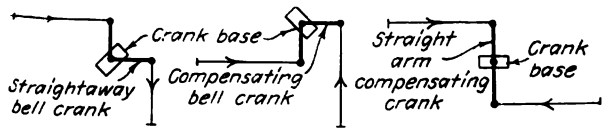
COMPENSATION. See Compensator.

COMPENSATOR. A device for counteracting the expansion and contraction caused by changes of temperatures in a long line of pipe or wire, thereby maintaining a constant length of line between units.

Where a turn is made in a pipe line, compensation may be provided for a certain section of the pipe line by the use of a crank, while in straight runs either a "lazy jack" compensator or a straight arm crank (in certain cases) may be used.

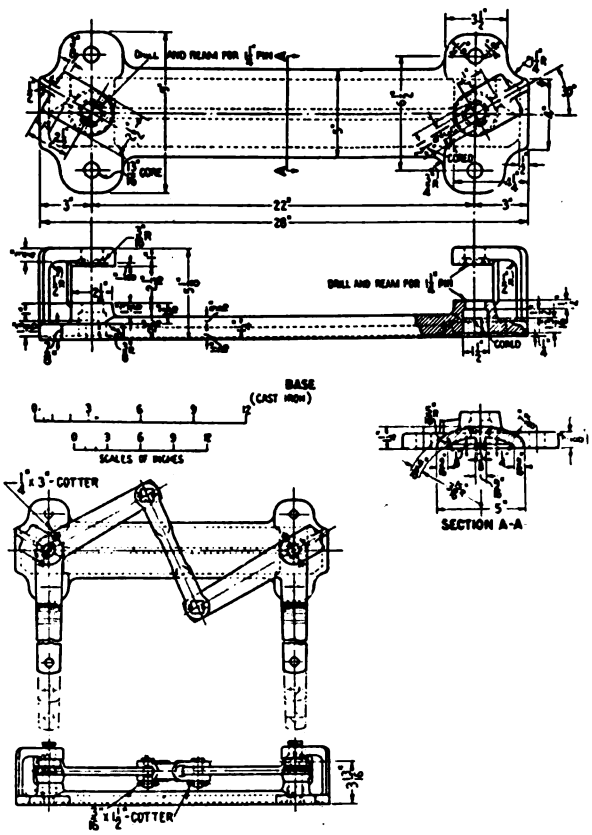
As the connection between a lever and its function is the equivalent of a solid iron rod, changes in temperature will cause expansion and contraction to take place and unless provision is made to counteract this tendency a pipe line may be too long in warm weather and too short in cold weather and thereby preventing levers and their units from making full strokes in one direction or the other. Serious variations in length may also often occur between morning and noon unless a pipe line is compensated.

A compensator reverses the direction of travel of the pipe line on one side of it so that expansion and contraction in different portions of the line counteract each other. A compensator may consist of a crank or a "lazy jack"; the latter consists of two cranks, one at 60 deg., the other at 120 deg., mounted on an iron base and connected by a short link. The "lazy jack" compensator allows the pipe to continue in a straight line while the direction of its motion is reversed. Pipe lines are sometimes compensated by the use of one or more cranks so arranged as to reverse the motion. Cranks are often used for this



Arrangement of Bell and Straight Arm Cranks for Compensation in Pipe Line

purpose in connection with pipe-connected derails. Cranks are designated as either compensating or straight-away. In connecting pipe lines it is customary to set all apparatus "on center" so that the throw may be equal in each direction; but to provide proper compensation and take care of all temperature effects the Railway Signal Association compensation chart as shown should be used, cutting the pipe long when the temperature is above the mean and short when it is below. In this way the throw



Details and Assembly of One Way Horizontal Type R. S. A. Compensator

will be equalized; otherwise the throw of the cranks will be further on one side of the center in warm weather than on the other side in cold weather. The diagram shows the effects of temperature on pipe

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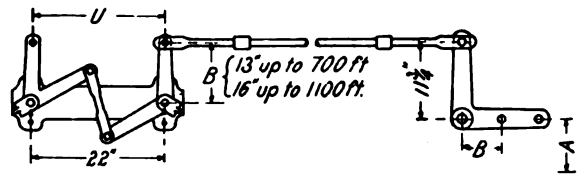
lines, temperature effects being based on a coefficient of expansion of iron of 0.08 in. per 100 ft. for 10 deg. F. In the diagram 40 deg. F. is considered the mean temperature but this varies in different localities and the mean temperature for a particular locality should



Note - Values of "U" are based on .08 of an inch as coefficient of expansion for an increase of 10° F. for each 100 ft. of line and nearest 1/16 is given

Length "A" in feet	Equivalents for "A" for Various Values of "B"											
	B-4"	B-4½"	B-5"	B-5½"	B-6"	B-6½"	B-7"	B-7½"	B-8"	B-8½"	B-9"	B-9½"
10	29	26	23	21	19	18	16	15	14	13	13	12
20	58	52	47	42	39	36	33	31	29	27	26	25
30	88	78	70	64	59	54	50	47	44	42	39	37
40	117	104	94	85	78	72	67	63	58	55	52	49
50	147	131	117	107	98	90	84	78	73	69	66	62
60	176	156	141	128	117	108	101	94	88	83	78	74
70	206	183	165	149	137	126	117	109	102	97	91	86
80	235	209	188	171	156	144	134	125	117	111	104	99
90	264	235	216	192	176	162	151	141	132	124	117	111
100	294	261	235	214	196	181	168	156	147	138	130	124

Compensation Table with Drawing Showing Application

be ascertained and used in connection with the R. S. A. compensation chart.

Among other items, the R. S. A. specifications for pipe compensation require that one way horizontal compensators or one way or two way vertical compensators may be used. Compensator supports on other than bridges or trestles shall be concrete foundations while the supports on bridges and trestles shall be governed by their nature.

Compensators shall be set so that the cranks will line true with the pipe line when the cranks are set to one-half lever stroke from 22-in. centers. Down rods in the interlocking station, at signals and on signal bridges shall not be considered in compensation. Compensators are to be spaced midway between pipe carrier foundations or supports.

In territory where the temperature variation is less than 120 deg. F., compensation shall be provided for each pipe line as follows:

(1) Lengths of 40 ft. to 700 ft. connected to switches, movable point frogs and derails shall have a compensator with 10-in. by 13-in. arms.

(2) Lengths of 700 ft. to 1,100 ft. shall have a compensator with 10-in. by 16-in. arms.

(3) Lengths over 1,100 ft. shall have additional compensators.

(4) Not more than 600 ft. of pipe shall be compensated by an 11¾-in. crank.

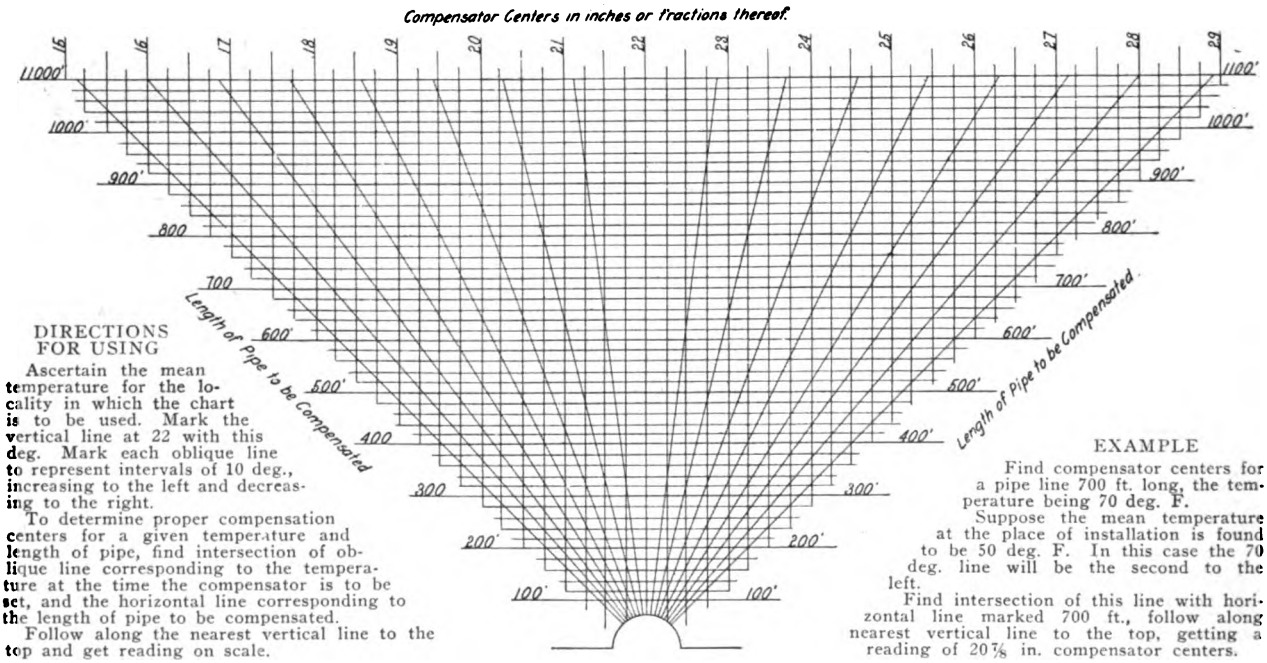
In territory where the temperature variation is more than 120 deg. F., compensation shall be provided for in each pipe line as follows:

(1) Lengths of 40 ft. to 500 ft. connected to switches, movable point frogs and derails shall have a compensator with 10-in. by 13-in. arms.

(2) Lengths of 500 ft. to 800 ft. with 10-in. by 16-in. arms.

(3) Lengths over 800 ft. with additional compensation.

(4) Not more than 430 ft. of pipe shall be compensated by an 11¾-in. crank. Compensation is to be provided in pipe lines in accordance with the compensation table. See Pipe Line.



Compensation Chart with Directions and Examples for Using

CONDENSER. A device for condensing or storing electrostatic charges, commonly accomplished by the use of sheets of a material which is a good

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conductor of electricity, separated by a non-conducting material which is called the dialectric. Condensers are used in connection with telegraph and telephone circuits, in induction coils on motor cars, etc.

Positive and negative charges of electricity attract one another and while electricity cannot flow through a non-conductor, it can act across it by induction. For example, if two pieces of tin foil are separated by a thin glass plate and one of them is positively charged with electricity while the other carries a negative charge, the two charges are attracted to each other and the tin foil can be charged to a much greater capacity in this manner than it would be possible to charge one only if it were stuck to the glass plate.

Electrostatic capacity is the name given this property possessed by two conductors of accumulating a large quantity of static electricity when placed side by side but separated by a non-conducting material. The ordinary condenser is usually made by taking a large number of sheets of tin foil, placing them face to face but separated by a non-conductor such as mica, waxed paraffin paper or other insulating material and pressing them tightly together, one set of sheets being then connected to one terminal while the alternate set is fastened to the other terminal.

COULOMB. A unit quantity of electricity that will pass in one second through a given cross section of a conductor carrying a unit current.

This practical unit of quantity is equivalent to the flow of one ampere per second in a given circuit. Thus five amperes flowing for one second will deliver 5 coulombs. One coulomb of electricity will liberate 0.001118 gram of silver which is the electrochemical equivalent of this element.

CUT SECTION. A complete track circuit forming part of a block section. This is a term commonly used in automatic block signaling for the track circuit where the block section is too long to maintain a single track circuit throughout its entire length because of the leakage of current through the ties and the roadbed being too great to allow for the proper operation of the relay. Thus a block section may be subdivided into two or more "cut sections", each of which may be made to repeat into the adjacent section through the track relay, or it can control directly the signal governing the block by breaking the line wire controlling the signal through the contacts on the track relay. See Track Circuit.

CYCLE (Electric). The complete change of direction made in an alternating current wave from any given value through zero to an equal value in the opposite direction and back. See Alternating Current.

D

D. C. The abbreviation used for direct current.

DANGER. A term formerly used to denote the "stop" indication of a signal, although rapidly becoming obsolete in signal termology, the term is still used in the combined term "normal danger", meaning an automatic block signal system, in which the signals indicate stop (or in the case of a distant signal, caution) at all times except when a train is approaching unless the block ahead is occupied. See Block Signal System, Automatic.

DEPOLARIZATION. The removal by any means of free hydrogen which tends to form on the negative element of a cell through the electro-chemical action which takes place in the cell. See Polarization. Also Cell.

DETECTOR BAR. A long, thin strip of metal mounted alongside the track rail usually on its outer side to prevent the movement of switches under trains.

The R. S. A. detector bar consists of three strips of metal, ½ in. by 2¼ in., two being 18 ft. 8 in. long with 6 in. offset sections for bolting together and the third a straight section of variable length. The overall length of the bar in general is from 53 to 55 ft., although shorter bars are used under special conditions, such as around movable point frogs and slip switches although in all cases the bars should be long enough to span the two trucks under the longest car which may operate over the road. The standard practice is to mount the bars in motion plate rail clips although the old practice was to use detector bar links which were short links supporting the bar, so fastened to the rail that the detector bar, when moving longitudinally, must also move upward and above the top of the rail.

The bar is so connected to the switch movement with which it is used that it must be lifted before the switch is moved. It is located in advance, in the rear or extends in advance of and in the rear of the switch. If any pair of wheels is on the rail along which it is mounted the bar is prevented from moving by coming in contact with the wheel tread which projects over the edge of the ball of the rail. If the detector bar cannot move, the switch cannot be moved and the arrangement, therefore, prevents the throwing of the switch under a car or train.

Detector bars are used with both mechanical and power-operated switches. They derive their name from the fact that the leverman in a mechanical interlocking can detect whether the detector bar is blocked by the pull on the lever.

There are two types of detector bars, the outside and the inside bar, both designed to perform the same function. The effectiveness of the outside bar depends on always having car wheels with treads wide enough to extend well outside of the head of the rail. The adoption of rails with wide heads has lessened the effectiveness of outside bars because with the width of the wheel treads only a little greater than that of the rail heads the bar may not be held down properly. This has led to the introduction of electric section locking involving electric track circuits controlling electric locks on the switch lever to serve the same purpose as the detector bar.

The ordinary detector bar prevents switch movement by the pressure of the outer part of the treads of the wheels of the car. The inside bar is controlled by the flanges of the wheel. The older form of this bar was arranged normally to lie flat, and in moving was turned upward by the movement of a long rod lying parallel to the bar and fixed to it. A later form is operated similarly to the outside bar. Inside detector bars are objectionable because, by reason of the presence of switch rods and other track accessories, it is impossible in many situations to put the

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bars where they are needed, and also because wheel flanges are not of uniform depth. For this and other reasons where detector bars are now employed the outside bar is more generally used. To be effective it must fit snugly against the rail head throughout its entire length.

The R. S. A. specifications require, among other things, that detector bars, when practicable, shall be so connected that the unlocking movement when the switch is in the main line position shall be in reverse direction to the facing movement of traffic over the points. Fifty-three-foot bars shall be mounted on 16 rail clips and a proportionate number of clips shall be used for longer or shorter bars.

The center of the rail clips shall be placed 8 in. and 26 in. respectively from the end and the remaining clips located approximately 3 ft. 9 in. apart.

Bars shall rise a minimum of ¾ in. above the top of the rail at every point during the locking and unlocking of the switch, and shall rest ¼ in. below the top of rail in every point when the lever travel is completed.

Where radial arm clips are used, combination bar stops and guides shall be provided, one for every 10 ft. of bar (equally spaced) and not less than two such stops on one bar.

The detector bar driving piece consists of a piece of open hearth steel 11¾ in. long with a 2¼ in. offset at one end and drilled with four holes at the other end for ⅜ in. button head rivets. The width of the driving piece is 2 in. Driving pieces shall be placed midway between two clips in the space not occupied by the jointed bar, and the driving rod shall have a length of not more than 7 ft. unsupported.

DOG CHART. A diagrammatic representation of the mechanical locking for an interlocking machine, used as a working plan in making up, assembling and fitting the locking.

The illustration under Locking Sheet shows dog chart for Improved Saxby and Farmer machine. The long horizontal lines represent the locking bars and are numbered in the order in which they are placed in the machine, commencing with the one next to the levers. A small circle drawn on this line shows by which lever the bar is worked and where the connection is made. Locking brackets are numbered to correspond with the levers. Cross locking is stamped with the number of the bracket in which it is to be placed. It is also stamped at each end with the number of the locking bar under that end. This is done in order that the bars and cross locking may easily be assembled or replaced in the machine if they have been removed for any reason. The cross locking is represented as being placed close to the dog by which the locking is performed; the clearance necessary to allow it to be moved is left next to the other dog. This is done in order to facilitate reading of the dog chart by showing which lever does the locking. When one lever locks two or more levers the cross locking is notched for as many dogs as there are levers to be locked. Reversal of the locking lever forces the cross locking over against the dogs of the other levers and locks them. If one of the other levers has been reversed, the cross locking will strike against the dog of that lever and prevent the lever from being reversed. See Locking Sheet.

DUMMY MAST. A bracket mast bearing no signal arm, its position relative to the other masts on the bracket post being used to indicate the track to which a signal applies. It may carry a distinctive light at night to fulfill its function. See Bracket Post, Cantilever. Also Bracket Mast.

E

ELECTRIC TRAIN STAFF SYSTEM. A block or series of consecutive blocks governed by the use of tokens which, when removed from the containing instruments and delivered to trains, confer authority for the use of the block; the release of the token from a machine being controlled by electric circuits between the two block instruments at adjacent stations so constructed as to require the co-operation of the block operator at each end of the block.

As defined by the Block Signal and Train Control Board this system is "a form of controlled manual block system for controlling train movements on single track."

This system is the safest single track manual block which can be installed. Its use in the United States is confined almost entirely to particularly dangerous stretches of single track such as through tunnels and gauntlets and short stretches of single track connecting double track and single track bridges. The operation of the system is based on the principle that for a train to pass safely over a given length of single track it should have in its possession a specific article conveying that right and of which there is only one obtainable while the train is occupying the block.

The above principle is worked out by the use of staff instruments, the improved type as mostly used in the United States being about 5 ft. 4 in. in height and 1 ft. 3 in. in width. Two each of these instruments are located at intermediate block stations, one for each direction, and one only at each end block station. Each instrument is equipped with from 10 to 35 staffs depending upon the traffic to be handled, each staff being 6 in. in length and weighing about 7 ounces. Instruments between stations are electrically connected and synchronized so that the withdrawal of a staff from one instrument must be accomplished by the concerted action of the two block operators and but one staff can be out of both instruments at one time.

In operation the track to be protected is divided into block sections of the proper length to accommodate the traffic. Block sections generally end at existing telegraph offices or stations, although when this distance is too great it is sometimes necessary to establish intermediate stations. A train moving from station A to station B must have in its possession a staff of this block. In removing a staff for this purpose the block operator at A presses a bell key the prescribed number of times required by the bell code which rings the bell at B. This is acknowledged by B on his bell key, which he then holds closed to deflect to the right a current-indicating needle on the instrument at A. This informs A that current has been furnished which will allow the removal of the staff. Before the staff can be removed completely its preliminary movement performs certain functions in

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the instrument which permit its final withdrawal from the machine. Before the staff is finally withdrawn the polarity of the operating current has been reversed and the instruments at A and B have been thrown out of synchronism and a staff indicating needle at A has moved from "Staff In" to "Staff Out". After withdrawing the staff, the block operator at A again presses his bell key, which moves the staff indicating needle on the instrument at B from the "staff in" to the "staff out" position, thus indicating to the block operator at B that the operation is complete. Under ordinary conditions the removal

Automatic Electric Train Staff Instrument, Front View
The Union Switch & Signal Co.

Automatic Electric Train Staff Instrument, Back View
The Union Switch & Signal Co.

of a staff occupies about five seconds while about two seconds is required to replace it.

The staffs are taken out by the block operator and delivered to the train by hand if it has stopped, or if it is not passing at more than 25 miles per hour. However, it frequently happens that delivery must be made to a train moving at high speed in which case it is necessary to place the staff in a special holder similar to a mail crane while the engine is fitted with a catching and delivery device. The staff may be placed in a leather or rubber pouch for delivery and when delivered by hand is usually placed in a pouch made of rubber hose shaped into a ring about 18 in. in dia. and handled in a manner similar to the rattan hoop used by operators in handing up train orders. It was formerly considered necessary to divide a staff and deliver one part to the engineman and the other part to the conductor so that if a train should break in two and part remain in the section the forward portion would deliver but one-half the staff which would not be sufficient to unlock the instrument, but practice now sanctions the delivery of the entire staff to the engineman. When the train reaches station B the staff received at station A is surrendered for another to govern from B to C. When the staff from A is placed in its proper instrument at B by the block operator he then presses his bell key the prescribed number of times, thus notifying the block operator at A that the train is out of the block. This operation also moves the staff indicating needle at A from the "staff out" to the "staff in" position. The block operator at A then presses his bell key in acknowledgment, and by so doing moves the staff indicating needle at B from the "staff out" to the "staff in" position, thus synchronizing the machines and another staff can be obtained from either station in the manner outlined. Four different designs of staffs are usually employed in actual practice to avoid the possibility of the staff belonging to one pair of instruments in a continuous installation being used to unlock one of another pair at either end of the block in immediately adjacent sections. Thus it would be necessary to

One Form of a Train Staff
The Union Switch & Signal Co.

carry one staff through three entire blocks before reaching one where it would fit an instrument.

Oftentimes it is desirable to allow one or more trains to follow another into a block under permissive signaling before the first train has passed out. In order to accomplish this a permissive attachment with one permissive staff may be added to the absolute staff instrument at each end of the block. In operating a permissive attachment an absolute staff is withdrawn in the usual manner and this is used to unlock the permissive attachment and to remove its permissive staff, the absolute staff being locked in the attachment until the permissive staff is replaced. This staff consists of a steel rod and 11 removable rings, one of which is given to each train, authorizing it to proceed. If less than 12 trains follow each other the last train takes the remaining ring and the steel rod. This is then reassembled by the block operator at B and placed in the permissive attachment, releasing the absolute staff locked in it which is then placed in the absolute instrument, again synchronizing the instruments. Should it again be necessary to move several trains permissively from A to B the permissive staff must be returned from B to A by the first train, the permissive staff conferring the same rights as an absolute staff.

Signals are often used to indicate to high speed trains whether or not staffs will be picked up at

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speed. When the arm is in the proceed position it indicates that a staff is ready for delivery but when it is in the stop position the train must stop and wait until one is released. A staff lever lock is frequently used in connection with each signal lever, the staff being used to open the lock, allowing the signal to be cleared, the staff being removed for delivery to the train.

A passing siding may sometimes be located between block stations which is of not enough importance to warrant the opening of a block office, in which case a special instrument is located at the siding. A train wishing to use the siding proceeds from A towards B with a staff in its possession and on reaching the switch uses the staff to unlock it. After closing and locking the switch the staff is placed in the special instrument which synchronizes the instruments at A and B, thus allowing any trains having precedence to be sent through the block in either direction.

Before the train can come out of the siding; A and B, working in conjunction, must release the staff in the siding instrument (which cannot be done if a staff is out between A and B) and this at the time prevents any staffs being removed from A or B. The siding staff is then used as a key to unlock the switch, this lock being so designed that the staff cannot be removed until the switch is set and locked for the main line, thus providing protection against misplaced switches. After the train has passed through the block to A or B the staff is delivered to the block operator who replaces it in his instrument, and this action again synchronizes the instruments the same as if the staff came from the other end of the block.

On heavy grades it is necessary frequently to use a pusher engine through a part of the block, this engine then returning to its original station. In such territory another adjunct known as the pusher engine attachment and staff is used. This is a separate device which may be attached to any absolute staff instrument and contains a staff of special design which can only be released by a regular staff. Although unlike the permissive staff it can be out of its receptacle at the same time as the regular staff. When the pusher staff is removed it opens the controlling circuits of the system, preventing any other movement being made until the regular staff has been returned to the instrument at B and the pusher staff has been relieved and locked in the pusher attachment.

At first there is an equal number of staffs in each instrument but as the train movement is generally greater in one direction than in the other a time would eventually come when all the staffs would be at one end of the block. To remedy this situation the maintainer unlocks the case and takes out an even number of staffs, which he transfers to the instrument at the other end of the block without in the meantime interfering with the operation of the instruments.

While the cost of an installation of this character is not as great as for automatic signals it is considerable, especially when block signals and staff cranes are employed. The staff system does not lend itself readily to territory where block offices are closed a part of the 24 hours, although this can be done by the installation of an additional instrument at station A (assuming station B is closed part of the time) and at station C, using a different staff than those used in the instruments between A and B and between B and C.

The electric trains staff system is a gradual development of the principle recognized in English railway practice as early as 1840 that if a train is to pass safely over a given position of single track it should have in its possession a token or tangible object conferring that right. The first train staff was a metal bar about two feet long which had the names of the stations between which it governed stamped or cast on it. In 1878 Edward Tyler introduced his electric tablet apparatus while in 1889 the Webb and Thompson electric train staff apparatus was introduced in which staffs were substituted for tablets and a permissive attachment added. The staffs for these instruments were 22 in. long and weighed 4 lb. each which made them difficult to catch at high speed. In 1900 an improved apparatus was introduced in the United States by the Union Switch & Signal Company employing a staff but 6 in. long and weighing but 6½ ounces. A later type of staff instrument was developed about 1904 and employed a staff of practically the same size and weight.

Unless otherwise provided the staff system supercedes time table superiority and takes the place of train orders. However if the system should be out of order trains must be moved by train order, giving them the right over all opposing trains to the next block station. Switching movements must be made only on the authority of a staff for the particular block in which these movements are to be made. The staff system, being a part of the controlled manual block system, is governed by the rules pertaining to the last named system.

A total of 461 miles of road was equipped with the electric train staff as of January 1, 1920. See Block System. Also Block System, Controlled Manual.

ELECTROMOTIVE FORCE. The force which starts or tends to start electricity in motion.

In order that electricity may be moved along a path a force of some kind must be present. The force may exist and still not cause any electricity to be moved; for example the electromotive force is just as real in a cell whether the wires attached to the cell are connected or disconnected. The intensity of the electromotive force varies considerably with the different kinds of elements and electrolytes used in cells. This makes necessary some unit by which comparison may be made between different cells or other sources used for producing electricity. This unit is called the volt. See Volt. Also Ampere.

F

FIBRE. A material used as insulation in insulated track joints, switch rods, signal apparatus, etc.

Fibre for this purpose is made from paper made only from cotton or linen rags. The R. S. A. specifications require, among other things, that it shall be seasoned for a period of not less than three months after being taken from the dry rooms. It shall be entirely free from chloride and glycerine as well as all other chemicals that will in any way tend to shorten its life or lower its insulating qualities under any condition of service. Fibre shall have a specific gravity of not less than 1.3 or more than 1.5 and it must stand

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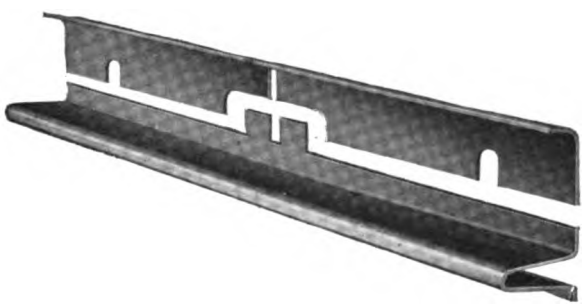
bending into a circle of a radius of ten times its thickness without cracking or splitting. When it is bent to the point of rupture it should break off square and not split. All surfaces where cut shall be square and free from burrs, fins, splits and other defects. The ends and edges of all pieces shall be sawed except holes which may be punched. Its electrical properties shall be such that under the application of voltage for one minute at the stated potentials between two disc electrodes, each one inch in diameter, the fibre shall not break down either by smoking, steaming, puncturing, or in any other manner fail under the voltage.

All fibre shall meet the following requirements:

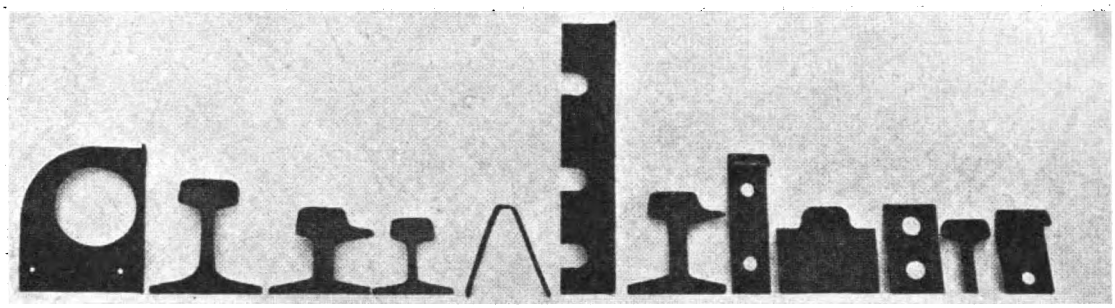
Thickness			Lb. Per Sq. In. Tensile Strength	A. C. Voltage pressure for one minute	Per Cent of Weight of Sample of Water Absorbed at 70 deg. F. shall not exceed for		
Nominal	Max.	Min.			3 hrs.	6 hrs.	24hrs.
.093	.103	.082	5000	3000	18	24	57
.125	.135	.113	5000	4000	14	20	45
.156	.166	.144	5000	5000	12	17	39
.187	.197	.170	5000	6000	11	14	30
.250	.270	.230	5000	8000	9	12	26

Fiber Insulation for Weber Joint



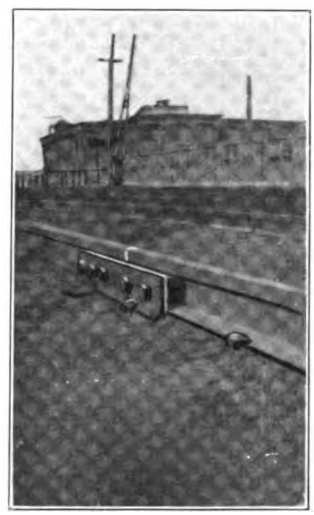
Insulation Plate Fiber for a Continuous Rail Joint
Diamond State Fiber Co.
(See Page 681)

The fibre shall be subjected to such chemical tests as may be necessary to insure that the requirements of the specifications are complied with. A test for zinc chloride is to boil a piece of fibre in pure water for 30 min. and then add ammonia to the solution. The presence of zinc chloride is indicated by a white precipitate.

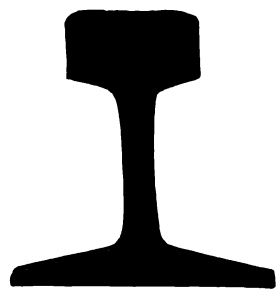


Typical Fiber Insulation. The Continental Fiber Co.
(See Page 672)

Before tests are made all samples shall be subjected to a temperature of 70 deg. for one week. Tests may be made at the mill or at the destination as the purchaser elects. A manufacturer must provide all apparatus and labor at the mill for making the required tests under supervision of the purchaser. For testing and inspection one piece shall be taken at random from each lot of 100 pieces or a fraction thereof and the results obtained will be taken as representing the entire shipment. The fibre pieces shall be packed in such a manner that they will hold their shape and be protected from the weather and from mechanical injury during shipment.



Insulated Joint in Track
Showing Fiber Insulation
The Diamond State Fiber Co.
(See Page 681)



End Post Insulation

Fibre Insulation

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FLUX, MAGNETIC. The number of lines of magnetic force that pass or flow through a magnetic circuit, or the total number of lines of magnetic force in any magnetic field. The magnetic flux is also called the magnetic flow. See Lines of Force. Also Ampere Turn.

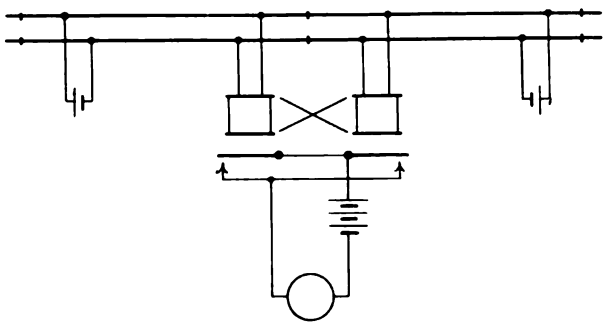
FREQUENCY. The term used to designate the number of cycles or alternations per second in an alternating current. The frequencies most used in commercial work are 25 and 60 cycles per second. See Cycle (Electric). Also Alternating Current.

G

GROUND SIGNAL POST. An ordinary signal post supported on a ground foundation as distinguished from one on a bridge, bracket post or other structure above the ground. See Signal Mast.

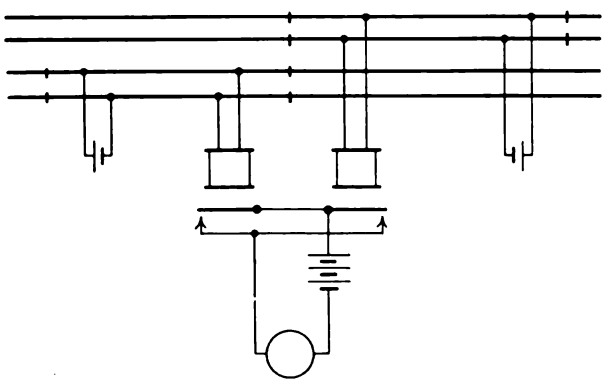
H

HIGHWAY CROSSING BELL. An automatic electric alarm designed to be placed alongside the track at a highway grade crossing to give advance warning of the approach of trains. This device is



Simple Crossing Bell Circuit for Single Track, Using Interlocking Relay

commonly a gong or locomotive type bell attached to a pole about 12 ft. above the ground, connected with a track circuit and set where it will be most effective as an audible signal to travelers on highways.



Simple Crossing Bell Circuit for Double Track, Using Ordinary Relays

The fundamental control of this type of highway crossing protection is embodied in the electric track circuit, which is composed of the running rails, bond-

Highway Crossing Bell, Enclosed Type
United Electric Apparatus Co.
(See Page 822)

Locomotive Type Motor-Operated Crossing Bell
The Bryant Manufacturing Co.

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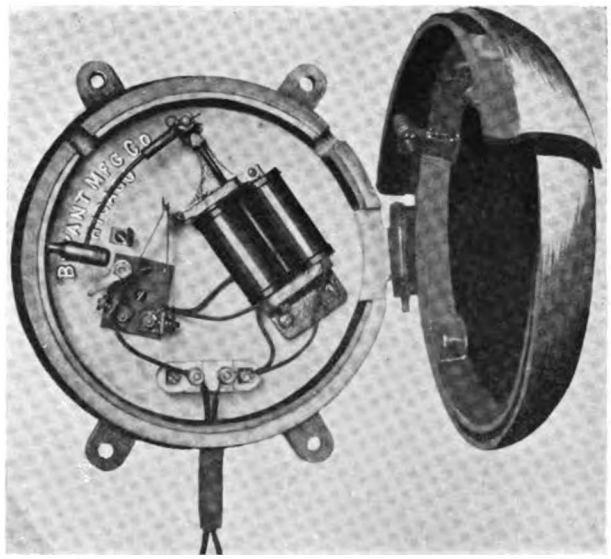
ed at each joint and provided with insulation at the bell location and at the starting points which are

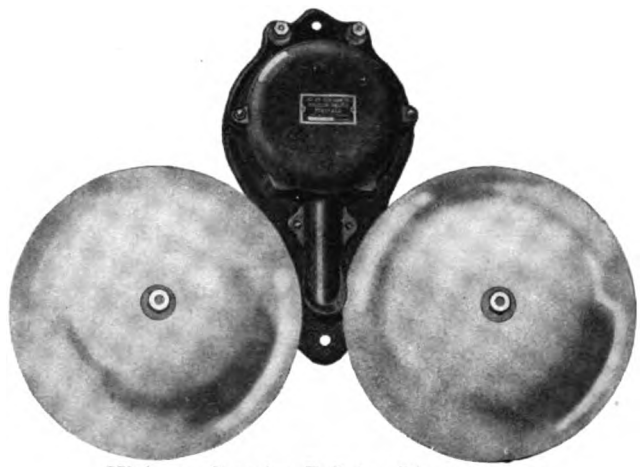


Vibrating Type Crossing Bell
The Bryant Manufacturing Co.

usually about one-half mile or more in each direction from the crossing, or far enough to allow time for the driver of a vehicle to clear the tracks ahead of a train. Electric cells at the starting points, contained in some form of battery housing below or even with the surface of the road-bed depending upon temperature conditions and the type of cell, furnish energy to the circuit which is connected with the bell by means of a relay consisting of an electromagnet and an armature with contacts and operating fingers. The wheels and axles of cars entering the track circuit shunt the electric current, thus preventing its flow through the relay and allowing the contact fingers to drop on the back contacts, which close the circuit through a local set of cells contained in some form of housing buried in the ground near the bell. Electrical energy from this set of cells flowing through the closed contacts rings the bell. After the train has passed the insulated joints at the bell location, the relay is again energized, picking up its armature and opening the local bell circuit by breaking the connection between the relay finger and the back contact on which it rested, thus stopping the bell from ringing. On single track, the relay is generally equipped with interlocking contacts, so that after the train passes into the succeeding track circuit, the contact fingers for that section are kept from resting on the back contacts to prevent the bell from ringing. See Relay, Interlocking. Also Relay. Also Track Circuit.

Highway Crossing Bell, Gong Type
The Railroad Supply Co.

Highway Crossing Bell, Locomotive Type
The Railroad Supply Co.



Highway Crossing Bell for Direct Current
The Schwarze Electric Co.

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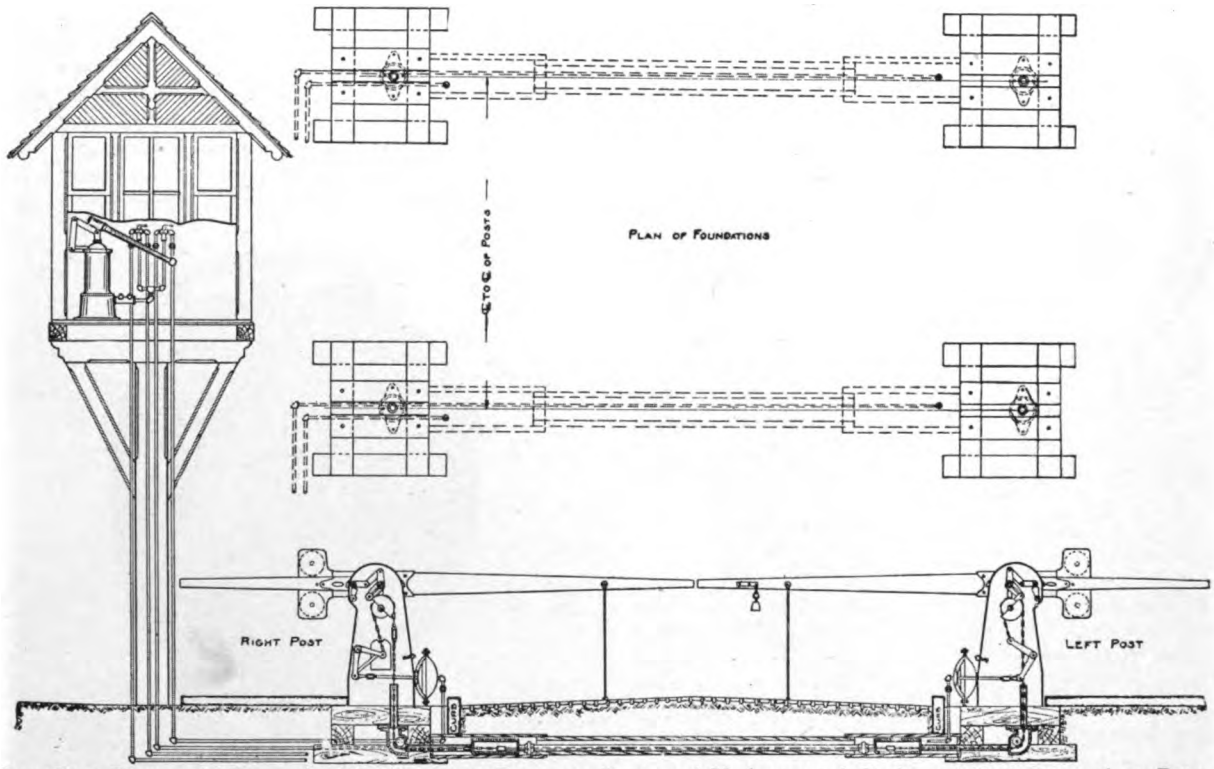
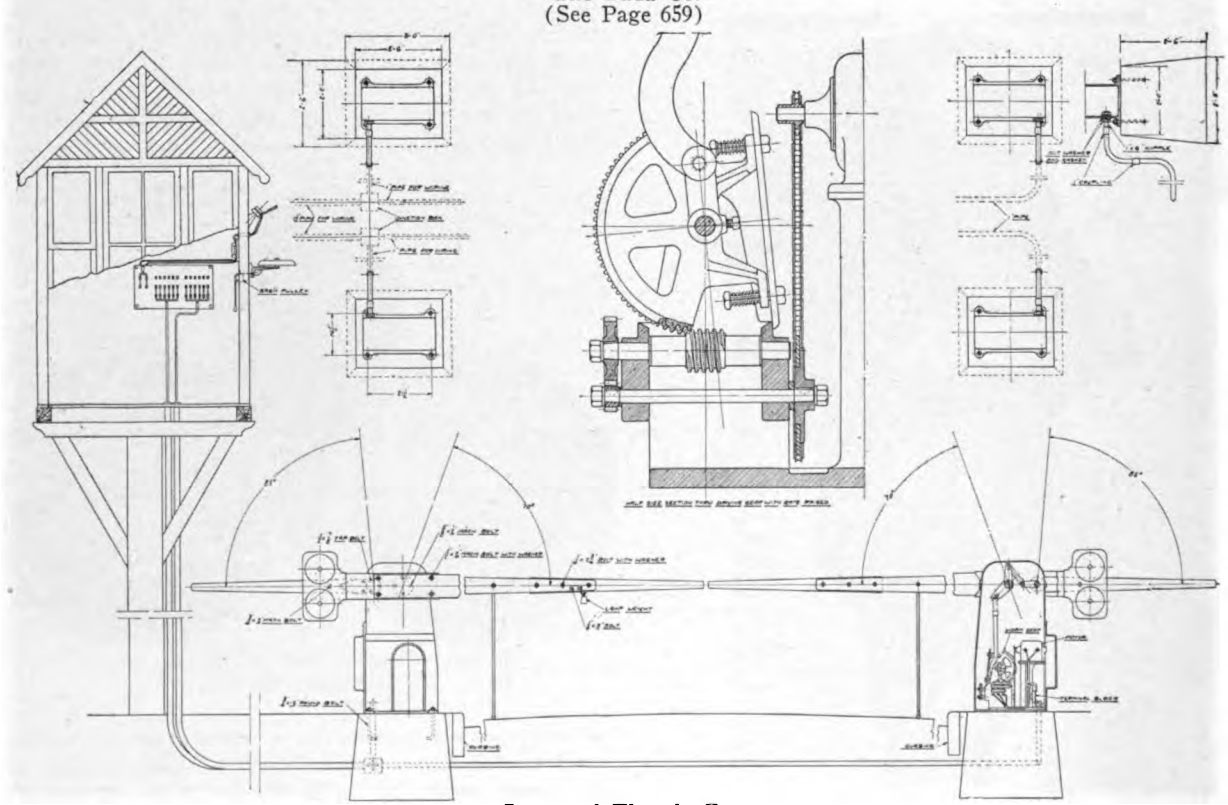
HIGHWAY CROSSING GATE. A movable barrier designed to be lowered across a highway or street to stop traffic over tracks at a grade crossing while trains are passing.

A common type of highway crossing gate, consisting of a long tapered wooden board pivoted to a bearing near the outer counterweighed end, is raised and lowered in a vertical arc at right angles to the



Four Post Pneumatic Gate, with Airpipes from Tower to Post, and Underground Chain and Rod Connections Between Posts Across Street
The Buda Co.
(See Page 659)



Improved Electric Gates
The Buda Co.
(See Page 659)

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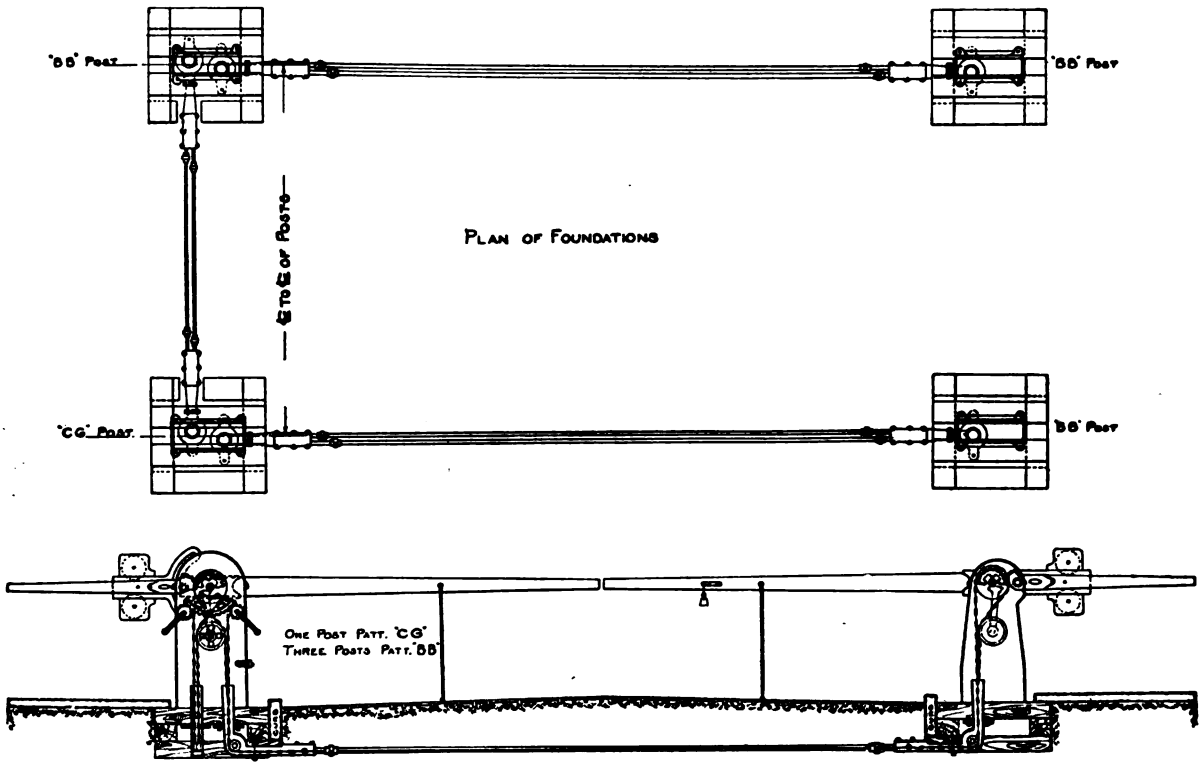
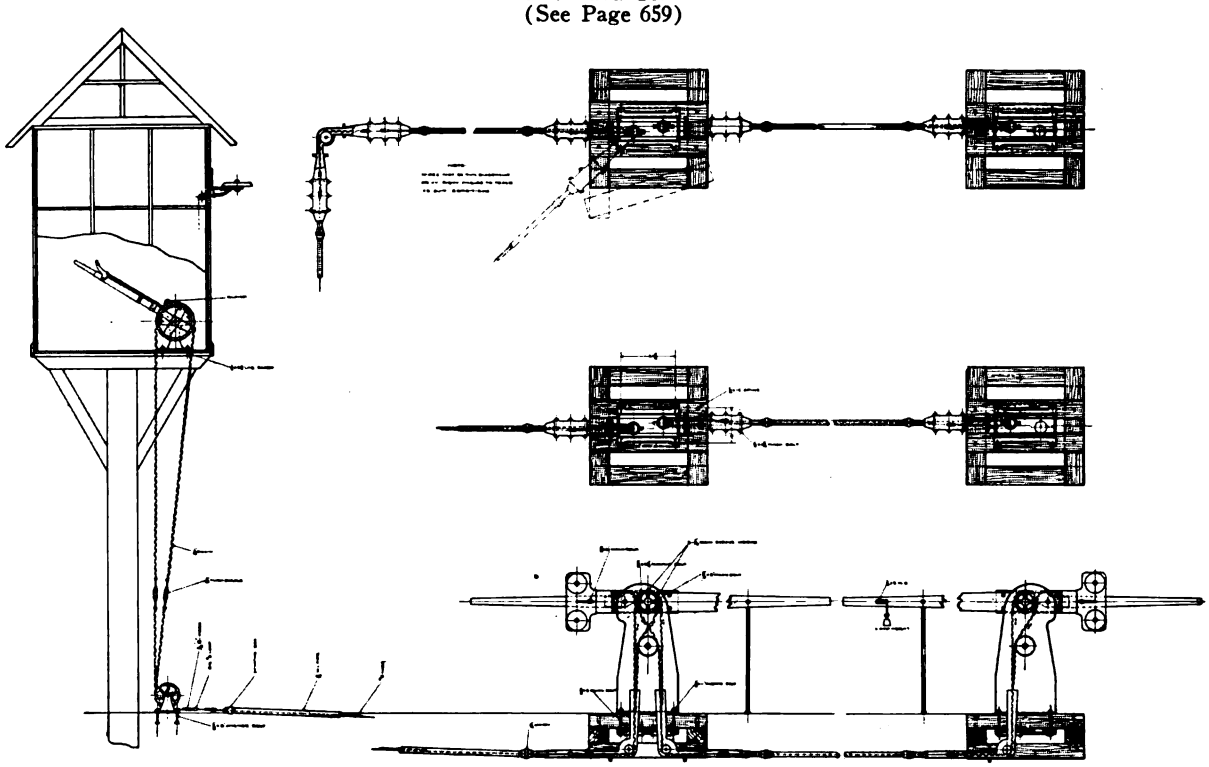
highway by means of a hand or power-rotating device. Frequently the highway is so wide that a pair of such gates is necessary, one pivoted at each side of the street so that the free ends almost meet in the middle of the road when lowered. A gate or a pair of gates is required on each side of the tracks to protect highway traffic from each direction. An iron rod about 3 ft. 6 in. long is frequently hinged to the crossing arm, about 10 ft. from its free end to act as a stop to hold the barrier from descending below the



Four Post Crank Gate Operated by Watchman on Ground
The Buda Co.
(See Page 659)



Four Post Lever Gate with Double Chain and Wire Connections Underground Between Posts and from Posts to Tower
The Buda Co.
(See Page 659)

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horizontal, while a lamp which displays red or other lights in line with the highway only is hung close to the end as a night warning signal. Sometimes a locomotive type of bell or gong is rung mechanically to warn travelers of the approach of trains at the same time that the gates are lowered. The barriers are also painted with alternating black and white diagonal stripes as a visual day signal.

HIGHWAY CROSSING PROTECTION. Equipment designed to promote the safety of persons using highways crossing railroads.

Highway crossing protection is generally provided at highways where the density of traffic is considerable and a number of trains pass daily. No hard and fast rules can be laid down governing the locations at which such protection should be installed. Protection is generally provided first at those highway crossings where the approach to the railroad is bad or the view is obstructed on one or both sides of the track. Different types of protection are provided, depending upon the local conditions, that installed at busy highways in cities differing from that at little used crossings in remote country districts.

The types of highway crossing protection most generally in use are watchmen; audible warning devices such as the gong type or the locomotive type highway crossing bell which operate automatically upon the approach of a train; highway crossing gates; a combination of a watchman and audible warning devices and the use of both audible and visual warning signals. Watchmen without gates are often employed at busy points in cities as well as the combination of a watchman and gates, but such protection is seldom installed at crossings outside of cities.

The audible warning, operated automatically upon the approach of a train, is often objectionable in residential districts and its greatest use is in the open country. With the advent of the automobile the audible warning did not prove sufficient and the next development was a combination of the audible and the visual warning, the visual warning being conveyed by means of a moving disc of the enclosed or open type, a flashing or moving light or a combination of both. In some instances visual warning signals only are installed. These signals, which are operated automatically on the approach of a train, are controlled by means of the track circuit with the necessary relays, batteries, etc.

An audible and visual annunciator or indicator is often installed in the gateman's shanty as an adjunct in order that the gateman may know when a train is approaching sufficiently in advance to enable him to lower the gates. Its greatest use is at places where the view is obstructed or the weather foggy. This indicator or annunciator is similar to that employed at interlocking plants. Highway crossing gates are operated mechanically, electrically or by air. See Highway Crossing Bell.

Three Aspect Flagman with Crossing Bell, Protecting Highway
The Union Switch & Signal Co.

HIGHWAY CROSSING VISUAL SIGNAL. A stationary, swinging or intermittent signal designed to warn travelers at a highway grade crossing

Three Position Wigwag Highway Crossing Signal
The Railroad Supply Company
(See Page 779)

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of the approach of trains; usually a sign or one or more lamps mounted on a pole or on a bracket attached to a pole and operated in connection with an automatic electric alarm bell.

Stationary lights are sometimes so placed as to throw their rays on the warning sign at the crossing; or they may be attached to a bracket in the form of an arc and dimmed one at a time in rapid succession so that the light flashes convey the impression of a swinging motion. They are usually controlled

Disc Type Highway Crossing Signal
The Hall Switch & Signal Co.

Flashing Light Highway Crossing Visible Signal
The A. G. A. Railway Light & Signal Co.

in connection with the electric alarm bell to flash as long as the bell rings. Another type is a lamp mounted on a swinging arm, automatically controlled in connection with the bell. The lamp swings back and forth in a plane at right angles to the highway, operating continuously with the bell as long as a train is in the track circuit.

Electricity is the usual source of power for lighting these signals, although gas is also used for one type of flash light signal and also sometimes for continuous signals.

I

IMPEDANCE BOND. A bond consisting of a coiled conductor connected around the insulated joints of adjacent track circuits on electrified lines allowing the propulsion current to pass unhindered back to the negative side of the power generator but impeding the passage of the alternating current used for signaling purposes.

This bond is used on double rail track circuits in electrified territory where both rails are employed for the return propulsion current and also for the track circuit. The bond is made up of a laminated iron core and two heavy copper windings, wound in opposite directions and so connected that the direct propulsion current flowing through it will neutralize the magnetic effect in the core. The alternating cur-

Impedance Bond
The General Railway Signal Co.

rent track circuit voltage tends to force the a. c. current through the windings but their connections are such that the coils offer an impeding or choking effect to the flow of a. c. signaling current from one rail of a track circuit to the other. This then allows the a. c. track circuit to be operated in a manner similar to a d. c. track circuit and at the same time without interfering with the direct return propulsion current.

Among other things, the R. S. A. specifies that when a bond has an air gap in its magnetic circuit, it shall be so designed that the air gap may be varied by varying the thickness of the air gap spacers and that separate windings which are insulated from each other shall withstand a potential test of 500 volts a. c. for one minute between their terminals, while all windings shall withstand a high potential test of 2000 volts a. c. for one minute between their terminals

Impedance Bond
The Union Switch & Signal Co.

and other metal parts from which these windings are insulated. Bonds intended for direct current propulsion shall be so designed that the propulsion current in one-half of the winding may exceed that in the other half by 20 per cent of the total (two rail) continuous capacity of the bonds without the impedance decreasing more than 10 per cent at the stated impressed signal voltage. The impedance and ohm's resistance of the bonds shall not vary more than 15 per cent above or below the values specified.

IN ADVANCE OF A SIGNAL. The section of track ahead of a signal over which its indication gov-

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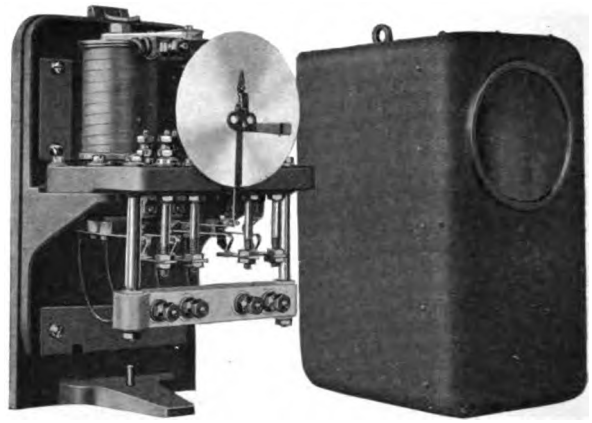
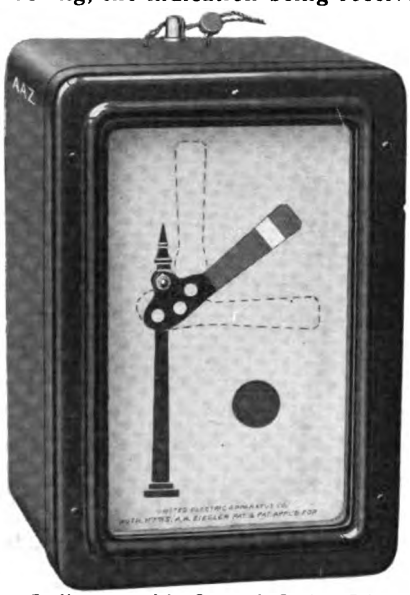
erns or that section of track occupied by a train after passing a protecting signal.

INDICATION. The electro-magnetic or pneumatic action produced in a power interlocking machine after a switch or a signal has been moved, indicating by releasing a lock on one or more levers that the switch movement or the signal movement has actually been completed. Indication is the expression also used in speaking of a signal aspect, the indication of a visual signal is what it tells an engineman on an approaching train. See Locking, Electric.

INDICATOR, APPROACH. A device used to announce the approach of a train at interlocking plants so that the leverman may be notified in ample time in advance to line up the route. Many roads consider this device a necessary adjunct of approach locking, the indication being received when the train reaches a predetermined point which may be one mile or less from a distant signal, depending on the requirements existing at the point of its installation. In automatic signal territory an approach indicator may be controlled through one or more track circuits or through circuit-breaker contacts in a signal, depending upon the scheme of approach locking employed. The approach indicator used in connection with approach locking should operate on a normally closed circuit so that a failure in the circuit will be on the side of safety. In non-automatic signal territory an approach indicator may be operated by a track instrument or by a short track section similar to that for an annunciator and on single track

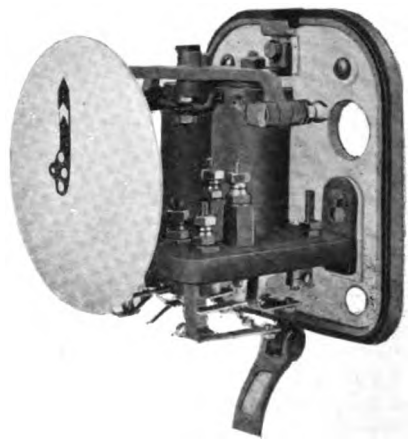


D. C. Tower Indicator
The Union Switch & Signal Co.



Indicator with Out of Order Disc
United Electric Apparatus Co.
(See Page 823)

Dumb Bell Type Annunciator
The Federal Signal Co.



Semaphore Type Tower Indicator
The Federal Signal Co.

Semaphore Type Indicator
The General Railway Signal Co.

Dumb Bell Disc Type Tower Indicator
The Hall Switch & Signal Co.

Semaphore Type Tower Indicator
The Hall Switch & Signal Co.

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roads where the indicator is to be operated only by trains approaching the interlocking plant, interlocking relays and short track circuit sections can be

Direct Current Indicator Group
The General Railway Signal Co.

used to advantage. See Annunciator. Also Locking, Approach. Also Relay, Interlocking.

INDICATOR, BLOCK. A device operating a miniature semaphore, disc or other form of indication to inform a signalman whether or not a particular block section is occupied by a train. The device is controlled by the track circuit, either directly or through the contacts of a track relay. The same devices are also used as annunciators. See Annunciator.

INDUCTION. The influence exerted by a charged body or by a magnetic field, on neighboring bodies without apparent communication.

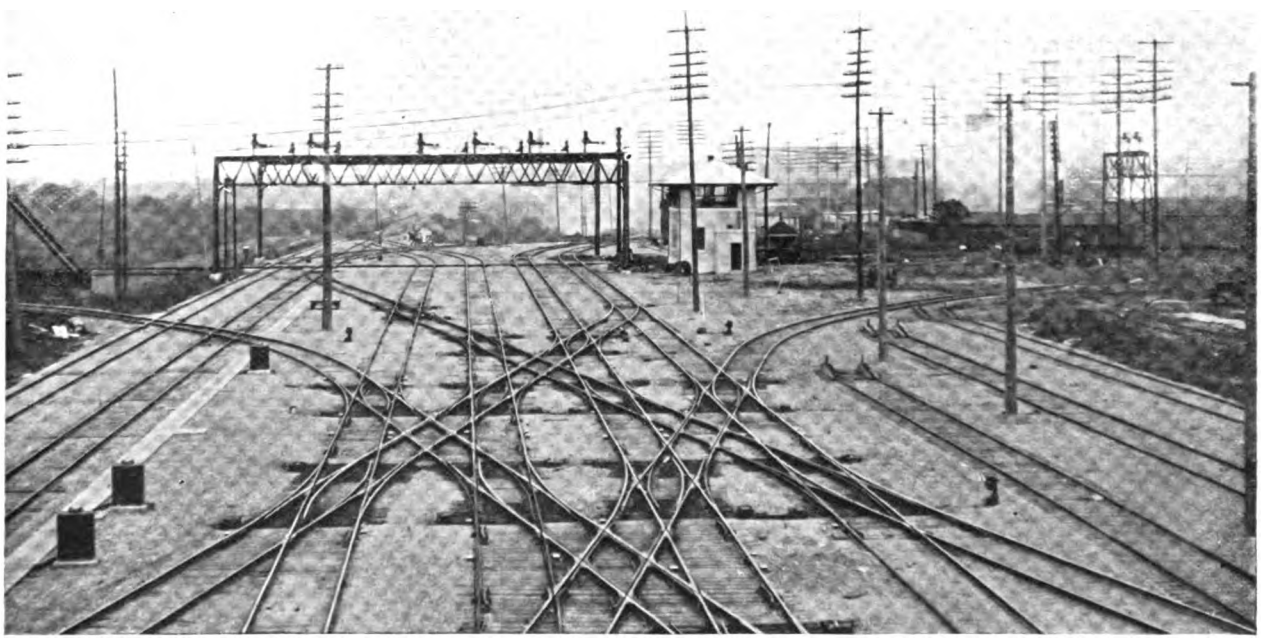
Induced currents are produced in closed circuits by the effects of a changing magnetic field. Induced currents may be produced in one circuit by increasing or decreasing the current in a neighboring circuit, or by causing a closed circuit to cut a magnetic field. See Lines of Force. Also Transformer.

INSULATION (Electrical). A material or substance used for the protection of electrical conductors from each other or other conducting substances and from grounds.

An insulation of rubber or other compound, paper, tape, etc., is used on single conductor wires and on wires in cables used in signal circuits while a fibre or other form of sheet insulation is used in connection with insulated joints, switch rods, pipe lines, etc., in order to prevent the current in a track circuit from passing from one rail to the other through switch rods, etc. See Wire, (Electric Conductors). Also Track Circuit. Also Fibre.

INTERLOCKING. "An arrangement of switch, lock and signal appliances so interconnected that their movements must succeed each other in a predetermined order." (A. R. A.). This term includes the tower, the machine, the switches, the signals and all connections and appurtenances.

The concentration of a considerable number of switch or signal levers in the hands of one man naturally results in the possibility of the leverman at some time mistaking the lever which he is to throw. Through such an error a train may be derailed or diverted from its proper course or a signal permitting a certain movement may be displayed at the same time another signal permitting a conflicting movement is given. To prevent occurrences of this kind, the various levers operating a number of switches and signals placed together in one frame or stand are so interconnected that only proper and non-conflicting routes can be set up. This interconnecting of devices used to operate switches or signals so that their movement can only occur in predetermined sequence is called "interlocking," and the



A Power Interlocking Layout with Slip Switches, Signal Bridges and 3-Position Upper Quadrant Signals.

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assemblage of stands, levers and connections is called an interlocking machine.

From the beginning, in about 1870, interlocking has made slow but steady progress. In the large passenger terminals it was soon seen to be an absolute necessity because without it the excessive cost of the wages of switchmen at detached switches, the danger of collisions due to imperfect hand signaling and to fog, and the intolerable delays necessary to guard against these dangers, often placed serious limitations on traffic. The early adoption of interlocking thus was largely induced by considerations of economy rather than of safety, and it was first introduced mainly at terminal yards, junctions and crossings. As the speeds of trains increased, interlocking has also been found useful at other stations necessity of slackening the speed of fast trains at such points.

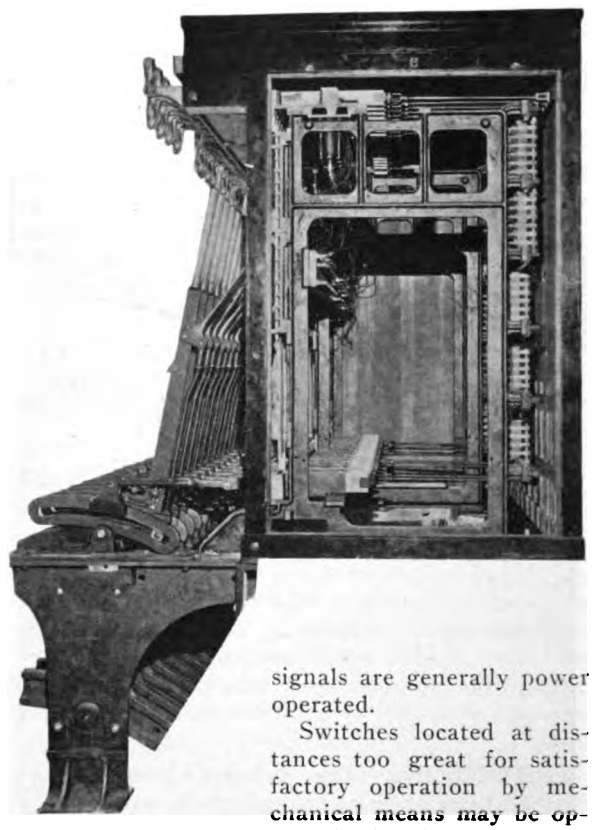
The interlocking tower, generally of two stories, is built of wood, brick or concrete and of the proper size to house the type of machine and its necessary fittings. The machines used may be divided into two general classes, viz.: mechanical and power; another type utilizing both mechanical and electric methods of operation is the electro-mechanical machine.

An interlocking plant is designated by the type of machine employed for its operation, as power interlocking or mechanical interlocking, etc. Five or six kinds of mechanical machines have been developed, the fundamental principles of operation being similar, and the chief difference being in the manner of their assembly. Four general types of power interlocking have been employed, viz.: hydraulic, pneumatic, electro-pneumatic, and electric. The first two are now almost obsolete, only a few of these designs being in service at the present time. Busy terminals and other places requiring power machines now employ either the electric or the electro-pneumatic type. Approximately 79 per cent of the total number of plants of all kinds are mechanical.

The selection of a power or mechanical machine depends upon local conditions, among which are the distances from the tower to the switches and derails which are to be operated and the number of the operations of the various functions. For these reasons it may be more economical to install a power plant at a place where but few levers are required, but which is a very busy point; and on the other hand a mechanical machine with a large number of levers may be more economical at a point where the traffic is light. See Locking, Electric. Also Locking, Mechanical. Also Interlocking Machine. Also Interlocking, Mechanical. Also Interlocking, Power. Also Interlocking, Electro-Mechanical.

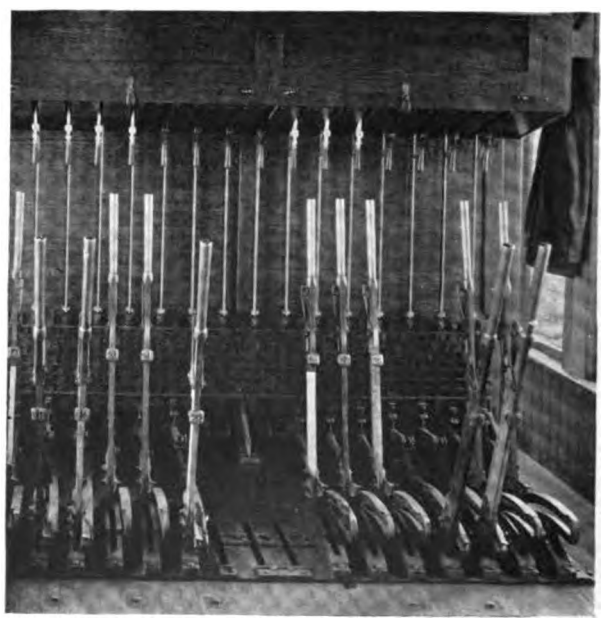
INTERLOCKING, ELECTRIC. Interlocking apparatus in which the switches and signals are operated by electric motors or by electric motors and solenoids (electro-magnets). See Interlocking. Also Interlocking Machine. Also Solenoids. Also Motor, Electric (General Section).

INTERLOCKING, ELECTRO-MECHANICAL. The general designation for the machine and other apparatus at an interlocking plant where part of the units are moved by means of rods by manual power while the other units are operated electrically. Usually switches are operated mechanically while the signals are generally power operated.



Electro-Mechanical Interlocking Machine
The General Railway Signal Co.

Switches located at distances too great for satisfactory operation by mechanical means may be operated electrically. This type of interlocking com-



Electro-Mechanical Interlocking Machine
The Federal Signal Co.

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bines the advantages of the flexibility of power and the ruggedness of the mechanical interlocking, and can be used to advantage in automatic signal territory as well as in existing interlocking towers too small to accommodate a proposed enlargement of the mechanical machine. The electro-mechanical machine consists of an improved Saxby & Farmer mechanical machine, above the levers of which are located a row of miniature levers which control the operation of the power-operated units. The electric levers and the mechanical levers must be so arranged that mechanical locking is accomplished between them. The locking may be actuated by the electric levers only

"P-5" Electro-Mechanical Interlocking Machine
Union Switch & Signal Co.

"S-8" Electro-Mechanical Interlocking Machine
Union Switch & Signal Co.

or by both the electric and mechanical levers. Various kinds of electric locking may also be employed. See Interlocking. Also Locking, Electric.

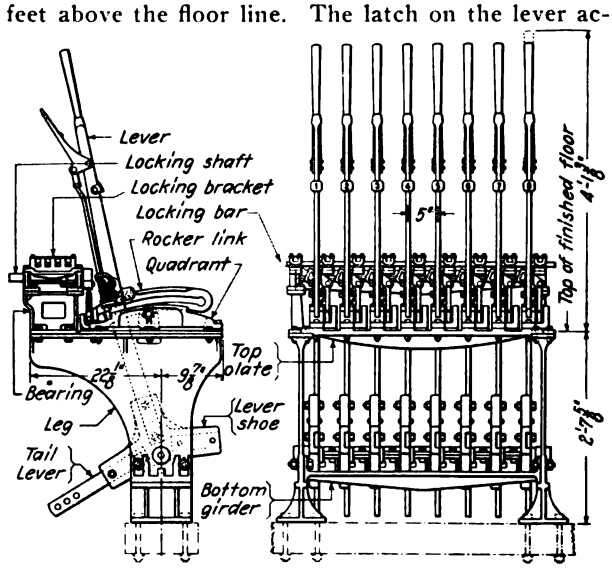
INTERLOCKING, ELECTRO-PNEUMATIC. Interlocking apparatus in which the switches and signals are moved by compressed air, but the air valves which control them are operated electrically from the interlocking machine in the tower. See Interlocking. Also Interlocking Machine.

INTERLOCKING MACHINE. An assemblage of switch and signal levers, in a frame, with connections so arranged that the movement of a lever, or its unlocking preparatory to its movement, may be made to lock any or all other levers in the frame. The interlocking is used to insure the movement of levers always in a pre-determined order, in lining up a route and in preventing the giving of a conflicting or dangerous signal indication by mistake or inadvertence.

Interlocking machines are of two general types, mechanical and power. Each type has the same fundamental units or parts performing certain functions. The parts consist of the frame, the levers, the locking bed and locking, and the operating connections. The frame forms the support on which the other essential parts of the machine are mounted. The levers, in addition to governing the mechanical locking, also operate the outside units by means of the proper connections which may be of a mechanical or an electrical nature. On mechanical machines the levers operate the outside units by direct connection with pipe lines while on power machines the levers actuate electrical contacts which close or open the various electric circuits designed for the operation of these units. In both classes of machines the mechanical locking may be of either the horizontal or vertical type. See Locking, Mechanical.

INTERLOCKING MACHINE, MECHANICAL. An interlocking machine so designed that the movement of the levers by means of manual power will operate the units on the plant through the agency of pipes or wires or both, which form intermediate connections between the machine and the operated units.

The principal parts of a mechanical machine consist of machine legs, girders, locking beds, brackets and locking bars and levers, the various parts being equipped with the necessary fittings and appurtenances. The levers are approximately six feet long from their bearings to the top and extend about four feet above the floor line. The latch on the lever ac-



Saxby & Farmer Mechanical Interlocking Machine
Showing the Various Parts

tuates the locking in order to provide the preliminary latch locking found on the standard types of machines.

The machines commonly used are the Improved Saxby & Farmer, the Standard (commonly called the Style A), the Johnson and the National. The Im-

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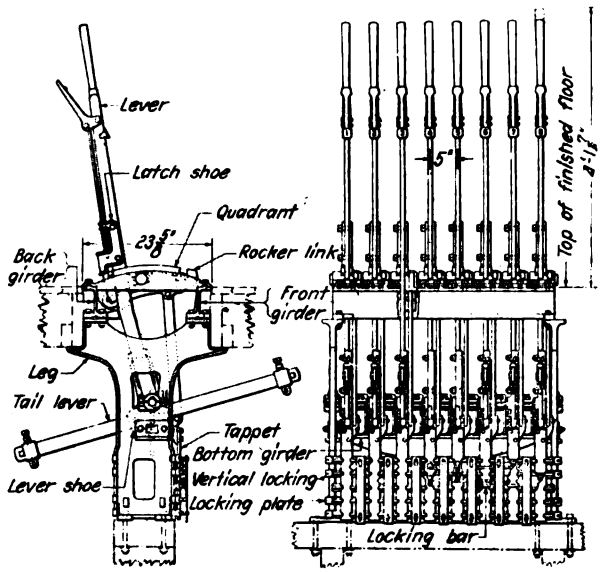
proved Saxby & Farmer machine is the one most generally used. The Standard machine is employed to a limited extent by some roads; while a number of Johnson and National machines are still in service, these types are rapidly becoming obsolete. The Improved Saxby & Farmer machine has mechanical locking of the horizontal type, while vertical locking is employed in the other machines. These machines are used in interlocking towers and stations for the operation of switches and signals and other



Details of a Standard (Style A) Mechanical Interlocking Machine

appliances at railroad crossings, junctions, station crossovers and passing sidings, yard entrances, drawbridges, etc.

In the Improved Saxby & Farmer type, with its horizontal locking bed, the locking is actuated by the movement of the latch handle which imparts an upward motion to the latch rod, rocker guides and to the universal links. This gives the rocker, which is pivoted at its center to the quadrant, one-half of its full throw. The rocker transmits an upward motion to the universal links which actuates the locking shaft, giving one-half of the throw to the longitudinal locking which in turn gives the full throw to the cross locking. When the lever is fully moved to the opposite position the latch handle, on being released, imparts the other half of the throw to the rocker and consequently to the longitudinal locking as well.

The movement of the lever itself does not transmit any motion to the locking. As very little power can be applied to the latch handle the strain on the locking is small compared with that on machines where the locking is actuated by the movement of the levers. The locking bars are numbered in the order in which they are to be placed in the machine, commencing with the one next to the levers, while locking brackets are numbered to correspond with the levers and the cross-locking is stamped with the number of the bracket in which it is to be placed. It is also stamped at each end with the number of the locking bar under that end. This is done so that the bars and cross-locking may be easily assembled or replaced in the machine if they have been removed for any reason.

Many parts of the Standard interlocking machine (commonly called the Style "A") are similar to those of the Improved Saxby & Farmer type. Unlike the I. S. & F. machine which uses the horizontal locking bed, this machine has a vertical locking bed. The latch lock and roller perform the same work as the foot of the latch rod and rocker guide in the I. S. & F. machine. The segment in this machine is of slightly different design but performs the same function as the quadrant used in the I. S. & F. machine. The rocker has a lug on one end which extends through and above the segment on which the leverman may step, thus raising the latch handle with less effort. The back and front girders support the segment, the back girder also acting as a stop for the lever. The locking plate supports the back and front locking and guides the tappets. The front locking guides are screwed to the locking plates to support and guide the front locking, while locking plate strips are placed in front of the front locking to hold it in place. The locking plates, which are attached to and supported by the machine legs, are constructed with four separate spaces for holding the locking bars.

The Johnson machine differs from others of the vertical locking type in that the tappet moves upward instead of downward when the lever is in reverse; also the rocker is connected to a bracket which is rigidly connected to the lever and therefore moves with it, the connection between the rocker and tappet having only a vertical motion. Preliminary latch locking is a feature of this machine.

The National machine is somewhat similar in design and operation to the Standard machine; the lever, the latch handle and its connection, the rocker and the link connecting it to the tappet varying only slightly in design. Locking plates are often provided on both sides of the machine legs and are operated as in the Standard machine.

Other types of machines, without preliminary latch locking, are employed for other uses. These may be classified as the Dwarf, the Stevens and the Style "C" machines.

Dwarf machines are designed for use at outlying switches and on elevated railroads where they may be set on ties or on low platforms and at the track level. They can also be used instead of the Stevens and the Style "C" machine except where a vertical leadout is necessary. As the Dwarf machine is made without preliminary locking, it is therefore without the quadrant, universal links, and locking bed attachments required where the refinement of latch locking is necessary. The Stevens machine is designed to operate and control a small number of switches and signals at points where the space for installing machines is limited or where it is found advantageous to control a number of yard switches from a central point. It can be operated from the ground level with horizontal connections or it can be set on a platform with vertical connections. The Style "C" machine is similar in design to the Stevens and is also intended to be used where it is desired to control a number of units in the yard, as from a location at grade where it is not always feasible to construct a tower.

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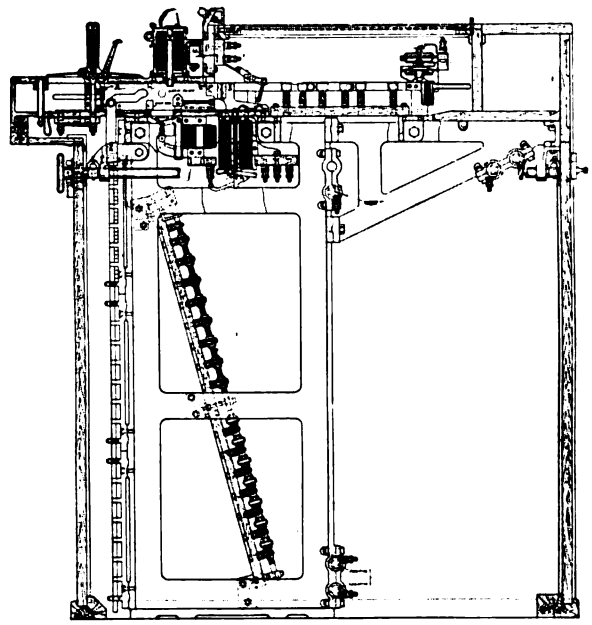
General Information and R. S. A. Specifications

When interlocking machines are ordered a signaled and numbered track plan should be furnished, drawn to a scale of not more than 100 ft. to the inch. Plans should show the location of the tower and the relation of the front of the machine to the track, which is that part of the machine occupied by a man when operating the levers. It should also indicate clearly the functions of each lever, the route or routes to be governed by each signal arm and the kind of connections for each lever. The number of levers and spare spaces must be included in the order and if special combinations of locking are required a locking sheet should be furnished in addition to the other information.

The R. S. A. specifications for mechanical interlocking machines require that like parts of machines of the same type shall be interchangeable; all bolts, tap bolts, and set screws shall be provided with jamb nuts and nut locks where it is practicable to apply them; one lever shoe pin and cap shall be provided for each spare space; one mechanical lever shall not operate more than one mechanical signal, two pairs of switch points, two full length detector bars, or two switch and lock movements and one full length detector bar; two 8-way mechanical bridge couplers; the combination of rail locks, bridge locks, mechanical bridge couplers and electric bridge couplers when the total load of such combination exceeds a load of two 8-way mechanical bridge couplers. Levers shall be numbered from left to right and so arranged that they can be removed without interfering with other levers. Spare levers shall be furnished in place complete ready for the operation and control of their respective units. Two position levers shall be latched in both normal and reverse positions. Three position levers shall be latched in the normal, central and reverse positions. Levers shall be 5 ft. 10⅛ in. from center of fulcrum to the end of handle and in machines of the same type all levers shall have equal and uniform throw and be so arranged that connections may be made to front or back of levers. Tail levers for pipe connections shall be drilled to provide for 8¾, 9¾ and 10¾-in. strokes. Provision may also be made for adding a counterweight of the right weight on mechanical switch levers which will assist in moving the lever to the normal position. See Locking, Latch. Also Interlocking Machine. Also Locking, Cross. Also Locking, Longitudinal. Also Locking, Horizontal. Also Locking, Vertical. Also Locking, Preliminary. Also Locking, Mechanical.

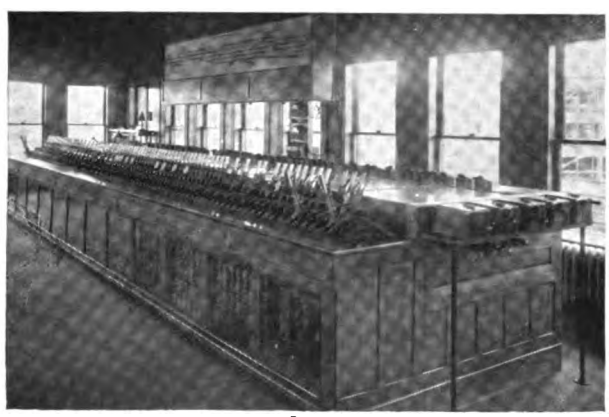
INTERLOCKING MACHINE, POWER. An interlocking machine so designed that the movement of the lever opens or closes electric circuits for the control of the apparatus, which is operated by some form of power such as electricity or compressed air or a combination of both.

Instead of the long levers required for the movement of switches and signals by manual power, small levers are employed in a power machine. These may consist of a sliding bar to which a handle is attached, or a short crank with a handle which merely opens or closes electric circuits through contacts to which these circuits are connected and which also operates the mechanical locking which is of lighter construction than that used in



Sectional View of Electric Interlocking Machine
The Hall Switch & Signal Co.

mechanical machines, because by the lever arrangement less strain is put upon the locking. The motion transmitted by the levers may be of a sliding character or through a quadrant of a circle, in which case a rotary motion is transmitted to the part opening or closing the contacts. The electric power plant has all units operated by electricity while on the electro-pneumatic plant, compressed air moves



Electric Interlocking Machine
The Federal Signal Co.

Electric Interlocking Machine
The General Railway Signal Co.

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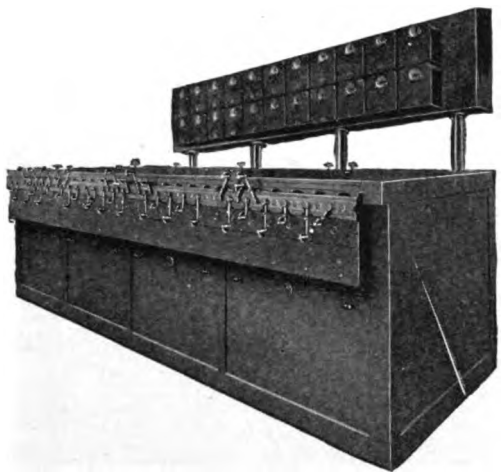
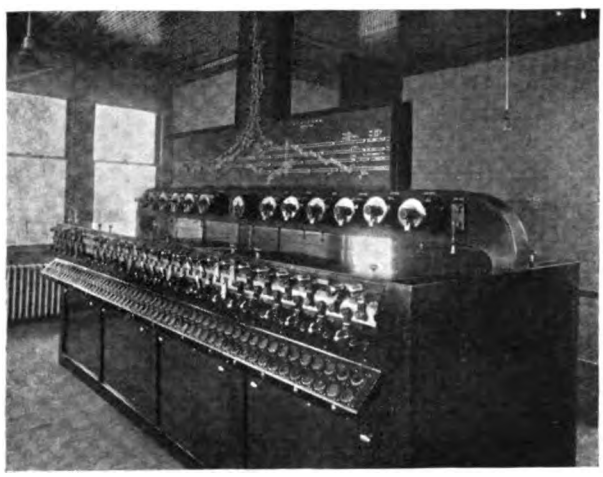
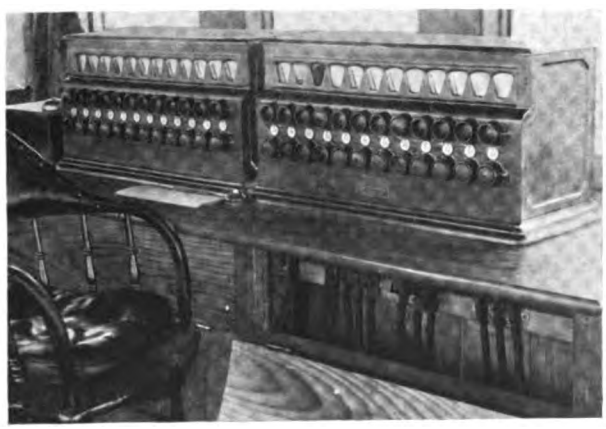
the switches and signals and the air valves are operated by electro-magnets controlled by means of electric circuits from the interlocking machine.



Electric Interlocking Machine
The Union Switch & Signal Co.



Electric Interlocking Machine
The Union Switch & Signal Co.



Push Button Electro-Pneumatic Interlocking Machine
The Union Switch & Signal Co.

Provision is also made for an indication to be received on the machine, showing the leverman that the unit operated has assumed a position corresponding to the position of the lever. This is usually accomplished by means of electro-magnets. Terminal boards to which the electric circuits are terminated are a part of the machine as well as circuit controllers for the operation of auxiliary

Electro-Pneumatic Interlocking Machine with Case
The Union Switch & Signal Co.

circuits. Voltmeters and ammeters are generally mounted on the machine to indicate to the leverman the power used in the operation of the different functions, and other auxiliary apparatus for various purposes is often mounted on the machine. Power interlocking machines are used extensively in terminals and at other locations where quick movements are required because of the density of traffic; where the space for the machine is limited, where the power is already available, and where units to be operated are located too far from tower to be handled mechanically. See Interlocking Machine. Also Interlocking. Also Locking, Mechanical.

INTERLOCKING, MECHANICAL. The general designation for the machine and the other apparatus at an interlocking plant where the switches and signals are moved by manual power by means of rods or rods and wires, as distinguished from a plant in which compressed air or electricity is the force moving switches and signals. See Interlocking.

INTERLOCKING PLANT. An assemblage of switch, lock and signal appliances interlocked. (A. R. A.). See Interlocking.

INTERLOCKING, PNEUMATIC. Interlocking apparatus in which both the power to work the switches and signals and the instrumentalities for controlling that power from the tower are actuated by compressed air. This type of interlocking is now obsolete, few plants being in service at the present time. See Interlocking.

INTERLOCKING, POWER. The general designation for the machine and other apparatus at an interlocking plant where the switches and signals are operated by means of compressed air or electricity, as distinguished from a plant in which rods or rods and wire, operated manually, constitute the force which moves the switches or signals. See Interlocking. See Interlocking Machine, Power.

INTERLOCKING STATION. A place from which an interlocking plant is operated. See Tower, Signal.

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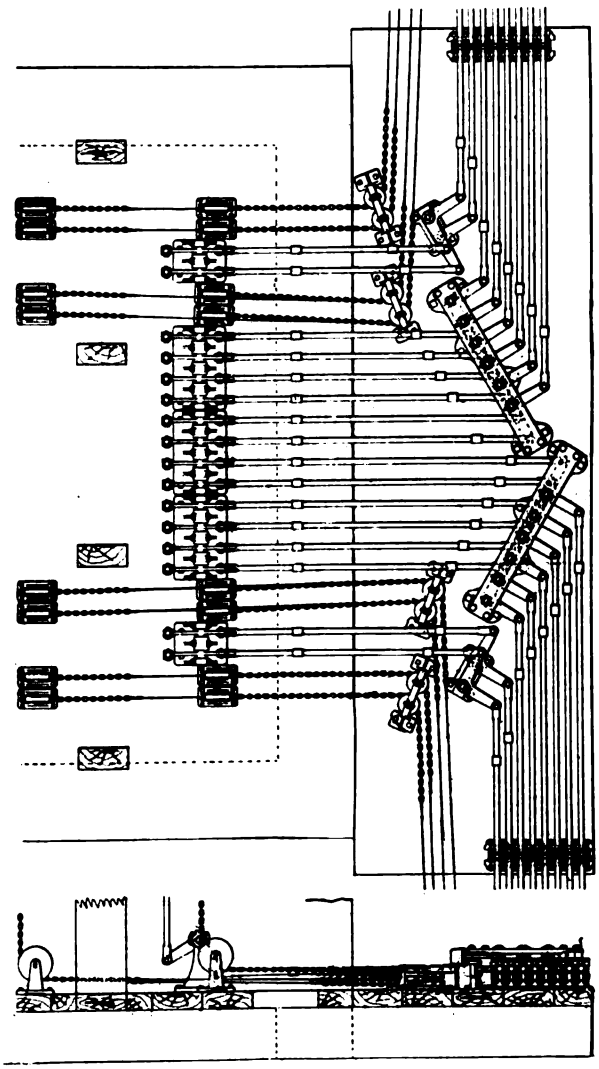
LAZY JACK COMPENSATOR. See Compensator.

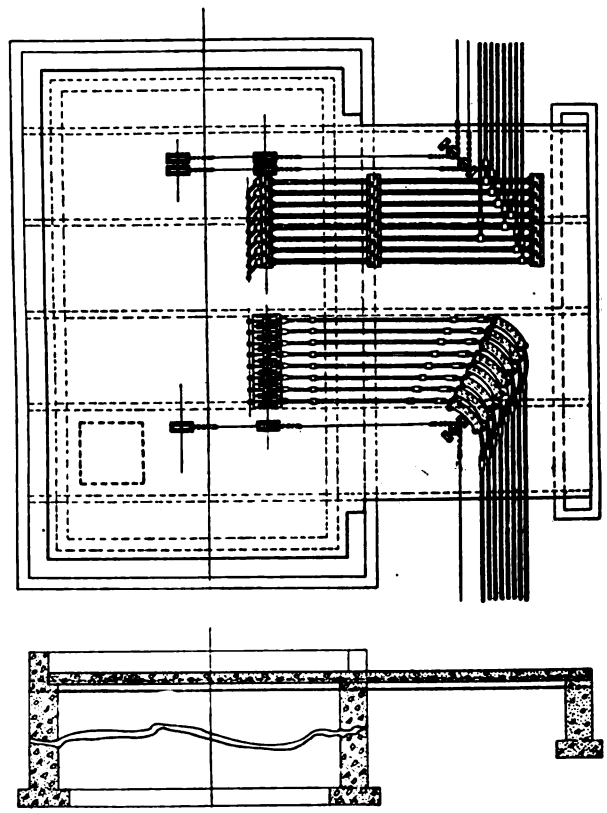
LEAD OUT. A term applied to the assemblage of pipe and wire lines and their supports and accessories in and near an interlocking tower which lead out from the tower to the switches, signals, etc., which they operate.

The leadout or arrangement of apparatus by which the operating connections are carried from the interlocking machine out of the tower consists of a foundation or platform forming an extension of the

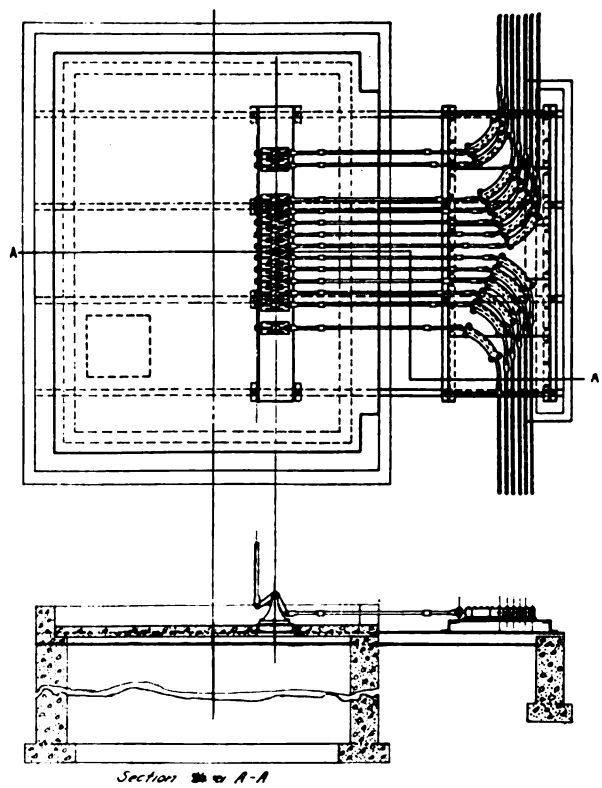


Leadout of Mechanical Interlocking Plant Showing Nest of Cranks and Chain Wheels

tower floor and the leadout devices mounted on it. These may consist of deflecting bars, rocker shafts or cranks or any combination of two or more of these devices. The rockers may be inverted where clearances demand. Rocker shafts are made of hexagonal or square steel bars, although the R. S. A. specifies a 2-in. by 2-in. square bar for this purpose. The rocker shafts carry offset and straight arms to which the vertical rods and pipe lines are attached. The straight arms are 7½ in., 9 in. or 11¾ in. long, while the offset arms are 9 in. or 11¾ in. long.



Leadout of Mechanical Interlocking Plant Showing Combination of Rocker Shafts and Deflecting Bars



Leadout of Mechanical Interlocking Plant Showing Deflecting Bar Arrangement

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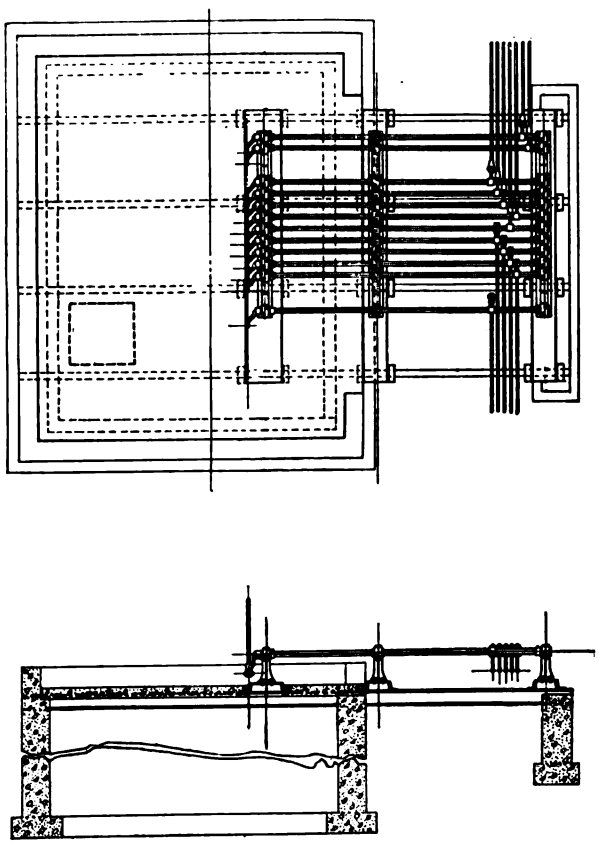
A crank leadout consists of one-way, two-way or three-way cranks or box cranks to which the pipe lines are attached, a box crank being a frame in which a number of cranks are mounted. A box crank leadout requires more space than a rocker shaft leadout, but it is more accessible. When box cranks are used the vertical rods must be attached to vertical cranks.

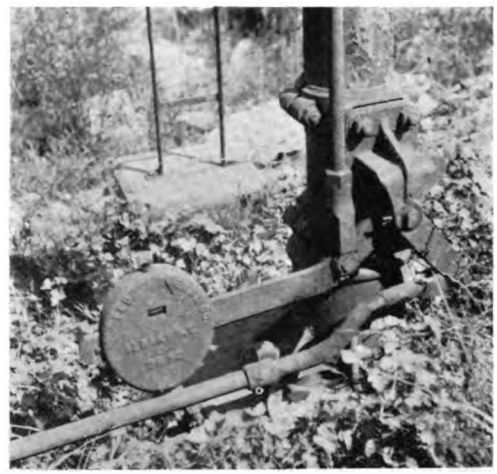
The connections between the lever of an interlocking machine and its unit, through which the motion is imparted, consist of pipe or steel wire. (Steel wire in America is used for signals only, and is rapidly becoming obsolete for this purpose.) More commonly lengths of pipe are joined together or to jaws, by coupling sleeves and rivets through iron plugs or through the tang end of the jaw. Thus a rigid joint is secured which does not depend on the threads.

The R. S. A. specifications require that down rods shall be of 1½-in. steel or wrought iron pipe with standard 1¼-in. jaws. The down rods shall be vertical with offset jaws for connection to levers for either 8¾ in. or 9¾ in. stroke, while the leadout appliances shall be securely fastened to the leadout supports with ¾-in. bolts with the bolt heads underneath. The vertical and horizontal cranks and deflecting bars, and the rocker shaft fittings must conform to R. S. A. standard drawings. Cranks for main pipe lines are to be drilled for 11¾ in. by 11¾ in. centers and not more than one crank shall be mounted on the same pin. Rocker shafts shall be supported by a bearing at each end, not more than six feet of shaft shall be unsupported, and the bearings are to be bolted securely to foundations with four ¾-in. bolts. See Interlocking, Mechanical.



Leadout of Mechanical Interlocking Plant Showing Rocker Shaft Arrangement

LEVER, BALANCE. The lever attached to a mechanically operated semaphore signal which carries the signal counterweight and to which the pipe or wire line is fastened which operates the signal. A counterweight is fastened to this lever when used in connection with lower quadrant signals to assist the signal to return to the stop position through gravity. The counterweight casting used on pipe-connected signals usually weighs 40 lb., and that used on wire-connected signals usually 10 lb., while counterweights of 9½, 10, 11, 16, and 20 lb. are used on balance levers for dwarf signals, the weight depending upon the design of the dwarf signal.



Balance Lever for Mechanical Signal

LEVER, CHECK LOCK. A separate lever in an interlocking machine which is used in connection with check locking. It is also called a traffic lever or master lever. See Locking, Check.

LEVER, GROUND. A switch or signal lever arranged to be handled by a person on the ground, as distinguished from a lever of an interlocking machine in a tower.

Such a lever may be single or double throw, with one to three levers to the stand, interlocked or non-interlocked with each other, and may be arranged for pipe or wire connections for the operation of the units. One type consists of a rack and pinion; another a rim-locked chain wheel to which the handle (or lever) is attached, while still another consists of a straight throw-over lever. Ground levers are used for locking an outlying switch and for operating the distant signal in connection therewith. The distant signal must first be set at "caution" and before the switch is thrown, and it cannot be cleared again until the switch is returned to its normal position. Ground levers are mounted on switch timbers at the switch points. See Signal, Distant Switch.

LEVERMAN. The attendant at an interlocking signal tower who also frequently performs the duties of switchman and telegraph operator.

LEVER, TRAFFIC. See Lever, Check Lock. Also Locking, Check.

LIGHTNING ARRESTER. A device to prevent or reduce damage to electrical equipment from discharges of lightning.

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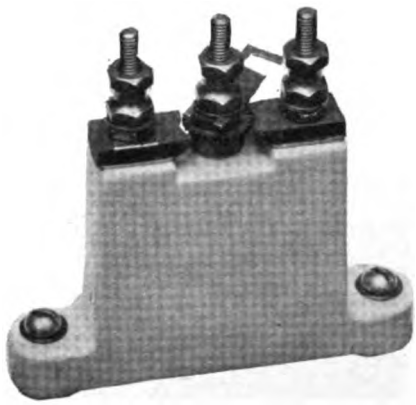
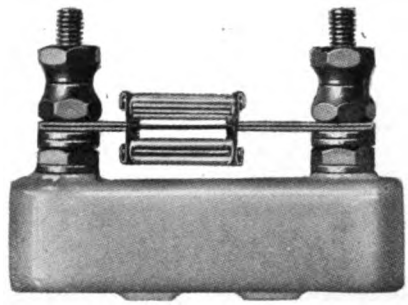
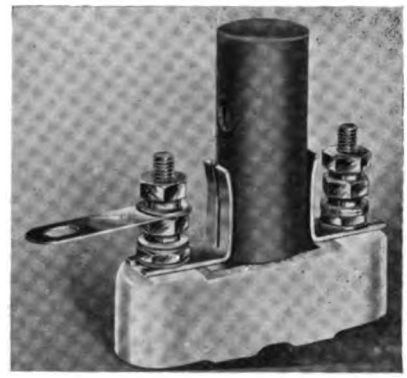


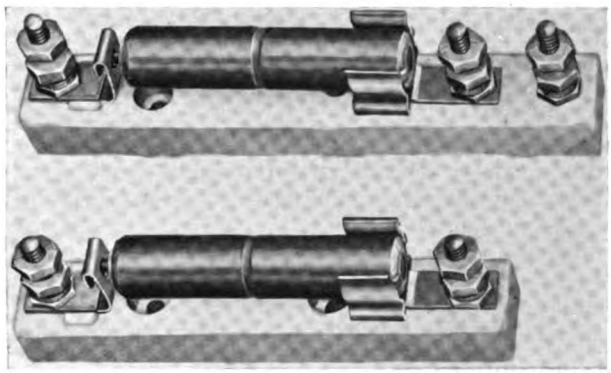
Spark Cap Lightning Arrester with Choke Coil
The General Railway Signal Co.



Lightning Arrester Mounted on R. S. A. Terminal Block
The Union Switch & Signal Co.

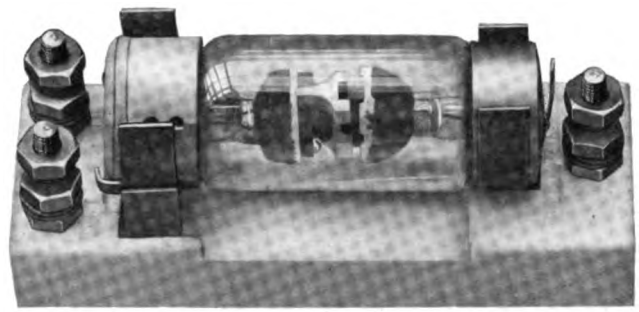


Jacobus Vacuum Lightning Arrester
E. Jacobus

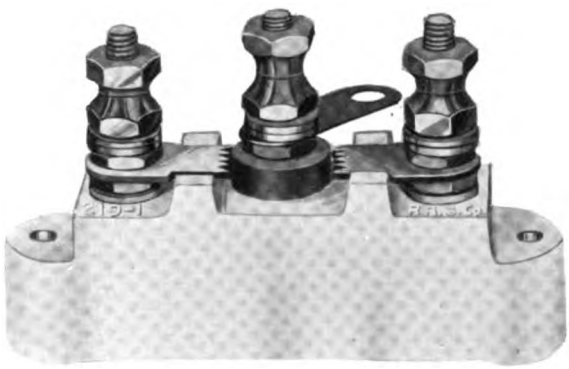


Vacuum Tube Lightning Arrester
The General Electric Co.
(See Page 695)

Vacuum Cartridge Lightning Arrester
The L. S. Brach Manufacturing Co.



Vac-M Lightning Arrester
The National Electric Specialty Co.



Choke Coil Spark Gap Lightning Arrester
The Railroad Supply Co.

Lightning arresters are of two kinds, spark gap and impedance arresters. The spark gap may be subdivided as the open type and the vacuum type, the gaps of the latter being enclosed in a vacuum tube, the vacuum reducing the breakdown point. Spark gap lightning arresters consist of two or more metallic plates with tooth edges placed in close proximity to each other, one or more connected to grounds, the others to the circuit to be protected. Impedance arresters consist of a coil of large sized wire which checks the lightning discharge. Sometimes a ground plate is placed near the coil so that the lightning may jump to it and thus reach ground. Lightning is a high potential alternating current. It therefore tends to jump across short gaps, especially from one metallic point to another; also it has difficulty in flowing through a coil on account of the high self-induction.

LINES OF FORCE. A unit of measurement of the intensity of a magnetic field, imaginary but of convenience in electrical calculations. Gauss is the term adopted for the Centimeter-Gram-Second unit of field density or strength, and is equivalent to one line of force per square centimeter. The intensity of the magnetic field is also spoken of in terms of the square inch, and the name Maxwell has been adopted in place of the expression "line of force." One square inch being equivalent to 6.45 sq. cm., a magnetic field having 4 lines of force per sq. cm. will have 25.8 lines per sq. in., or 25.8 gausses. If the field density is equivalent to 4 lines of force per sq. cm. it may be said to have a strength of 4 gausses, but if it has a strength of 4 lines of force per sq. in., it may be spoken of as 4 maxwells per sq. in., but not as 4 gausses per sq. in.

Lines of force flow out of the north pole through

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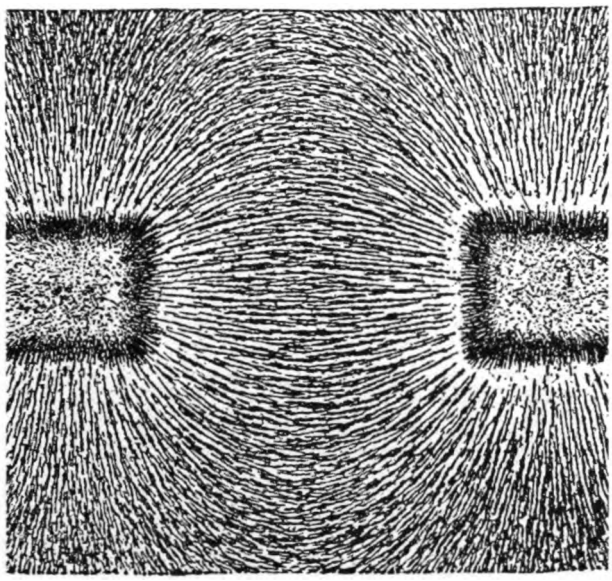
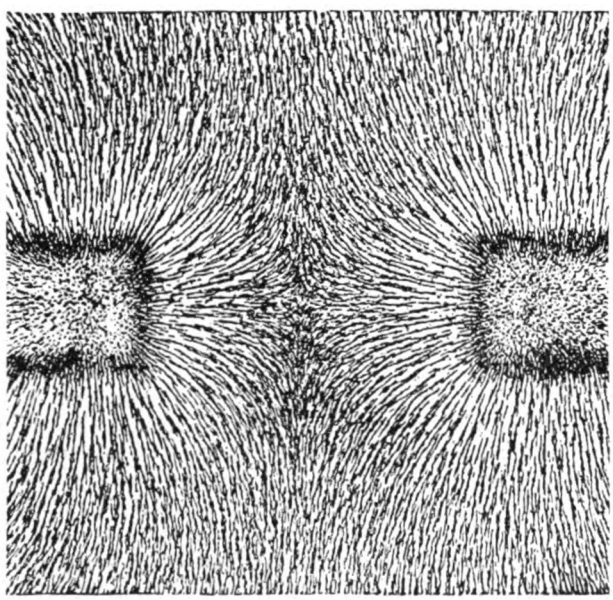
the surrounding medium to the south pole and back through the magnet to the north pole. Each line of force may be considered as a complete magnetic circuit; the lines never cross, but tend to push one another sideways and have longitudinal tension.



Illustrating Lines of Force Between Unlike Poles or Magnetic Fields

The magnetic field is that space outside of the magnet which is traversed by the lines of force. The field strength increases in direct ratio to the number of lines of force per square centimeter. Hard



Illustrating Lines of Force Between Like Poles or Magnetic Fields

steel is not as good a conductor for lines of force as is soft iron or steel, and the number of magnetic lines produced in soft iron by a given number of ampere turns is much greater than would be produced in a similar piece of hard steel by the same number of ampere turns. The current generated in the armature of a dynamo is due to the fact that the armature coils cut the lines of force of the magnetic field set up by the poles of the dynamo and the strength of the current is proportional to the number of lines of force cut per second. See Ampere Turn.

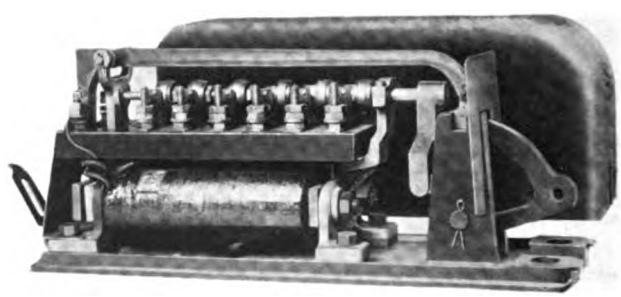
LOCAL ACTION (in a Cell). Any non-productive internal chemical reaction tending to decompose the elements of a cell; caused principally by (1) commercial zinc containing foreign particles; (2) a metal in two dissimilar electrolytes; (3) two metals in the same electrolyte; (4) a diffusion of different electrolytes.

The remedy for (1) is amalgamation of the zinc. An example of the second case occurs in the gravity cell when copper sulphate solution is about half way up on the copper element, while the other half of the copper is in the zinc sulphate solution. The remedy is the addition of copper sulphate crystals, and the reduction of the zinc sulphate solution. The third case may occur where a copper deposit forms on the zinc element, both metals being in the zinc sulphate solution in the gravity cell. This may be caused by the cell being improperly set up, or from standing on open circuit for some time. The remedy is to set up the cell properly or not to allow it to stand on open circuit. An example of the fourth cause is the diffusion of the copper sulphate and zinc sulphate solutions. As diffusion takes place the copper sulphate solution finally comes in contact with the zinc element on which the copper and zinc displace each other. The remedy for this condition is the same as for the third cause. See Cell, Gravity. Also Cell, Caustic Soda. Also Cell, Caustic Potash. Also Cell, Storage. Also Cell, Dry.

LOCK AND BLOCK. A name commonly employed for the controlled manual block system. See Block System, Controlled Manual.

LOCK, ELECTRIC. An electro-magnetically operated device used under certain conditions to lock a lever of an interlocking machine, an outlying switch or a drawbridge, to prevent improper manipulations of the unit to which it is applied.

An electric lock consists of an electro-magnet used to actuate a locking dog which works in conjunction with a locking segment or a sliding bar notched to lock the lever; or to function in one or



Electric Lock with Circuit Breaker
The Federal Signal Co.

more positions by allowing the locking dog to engage in the notch when the electro-magnet has no electric current flowing through it, thus preventing

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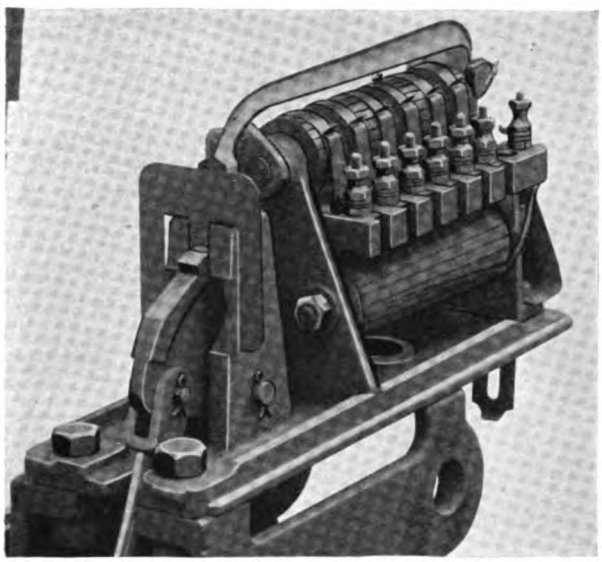
the lever movement beyond that point. When applied to an interlocking machine, an electric lock may be arranged to lock any lever in the following positions: (a) normal, (b) reverse, (c) normal and reverse, (d) half normal and half reverse, (e) half

Electric Lock in Case
The Federal Signal Co.

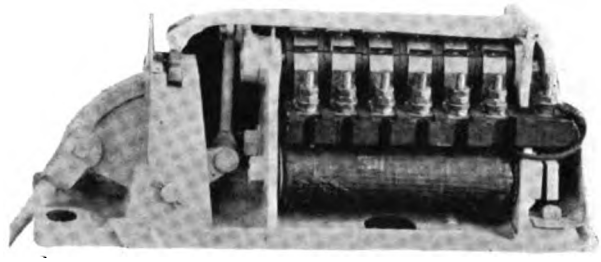
normal, (f) half reverse. It may be used in connection with any of the levers in the machine. Such a lock is separate and distinct from the mechanical locking of the machine and is provided as an additional operating safeguard.

An electric lock is called a normal lock when arranged to lock a lever in its full normal position; a reverse lock, when arranged to lock it in the full



Electric Lock
The Union Switch & Signal Co.

reverse position; while a normal and reverse electric lock will lock a lever in its full normal and full reverse positions. A half normal electric lock is so arranged that a lever may be placed at full normal, but it cannot be fully reversed, while a half reverse lock is so arranged that a lever may be reversed but cannot be returned to the full normal position. An indication lock permits lever movements between the normal and reverse latching (or indication) positions. While allowing the free movement of a lever to operate the switch or signal to the normal or reverse positions, this lock prevents the full movement of the mechanical locking. Combinations of these types of locks are often employed to



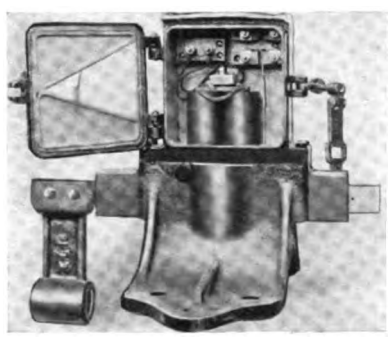
Electric Lock with Circuit Breaker
The General Railway Signal Co.

meet certain conditions, one frequently used being the full normal and half reverse locking. Machines employing direct lever locking without preliminary locking movement may be equipped with electric locks which will lock the lever in the full normal or the full reverse positions. See Locking, Electric. Also Locking, Mechanical.

LOCK, FACING POINT. A lock (sometimes abbreviated F. P. L.) for an interlocking switch worked or controlled by the leverman, so called because used chiefly at facing point switches and seldom or never at trailing point switches.

In and near large terminals all switches are provided with these locks, as these switches are frequently traversed by trains in both directions. The operating connection of a switch ordinarily holds it in position; the lock is an additional provision for insuring accuracy of movement. At a trailing point switch extreme accuracy is not essential.

LOCK, ELECTRIC SWITCH. An electric lock controlled from a signal tower or station building and attached to the operating connection of an outlying switch to prevent the switch from being moved without the knowledge and consent of the leverman or station operator.



Outlying Switch Lock
The Union Switch and Signal Co.

Electric switch locks are generally used at mechanical interlocking plants to control outlying switches and crossovers which are located between signal limits (such as home and distant signals) at too great a distance to be operated safely with mechanical connections or at power interlocking plants under similar conditions, or where it is felt that the expense to make them part of the interlocked units is not warranted. Switches so locked are under the control of the leverman. Such switches may be operated by a one-lever dwarf machine fitted with an electric lock, locking it in the normal position or by a switch stand and the use of a special electric

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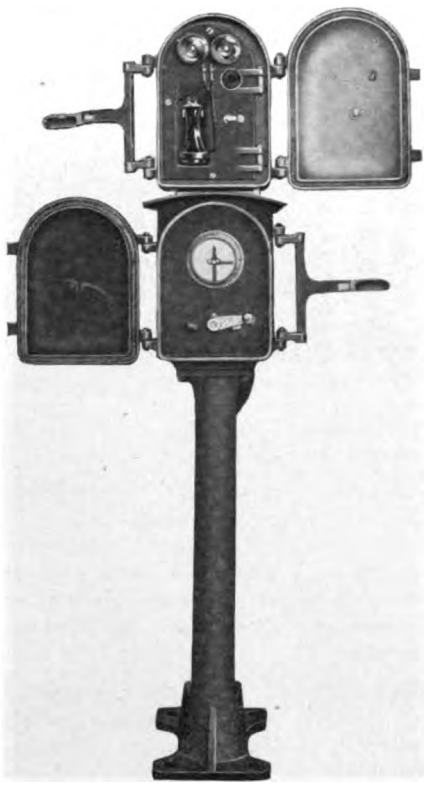
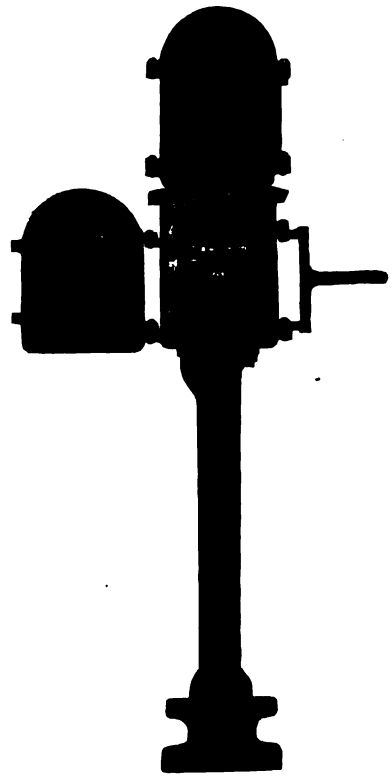


Outlying Switch Lock, Front View
The Union Switch and Signal Co.

Outlying Switch Lock
The General Railway Signal Co.



Outlying Switch Lock, Rear View
The Union Switch and Signal Co.

lock. The switch locks are provided with electric contacts for the control of circuits which generally are employed to indicate to the leverman in some manner that the switch has been placed normal and locked in that position. The lock may be controlled from the tower by means of a hand switch; a lever in the interlocking machine, or a hand circuit controller, which is usually electrically locked by the switch lock. A telephone or a key and bell are usually added in the mechanism case at the switch to provide a means of communication between the switch and the tower. A condenser is sometimes employed with the telephone and the bell circuit, or the switch lock control circuit is used direct for the telephone circuit. See Locking, Electric. See Condenser.

LOCK, OUTLYING SWITCH. An electric switch lock applied to an outlying switch. See Lock, Electric Switch. Also Locking, Electric.

LOCKING. The arrangement of rods, bars, dogs, tappets, electric locks and other apparatus in and on an interlocking machine, designed to prevent a leverman from throwing conflicting switches and signals and to insure the integrity of a route, or portion of a route, during the movement of a train over that route. See Locking, Mechanical. Also Locking, Electric.

LOCKING, APPROACH. Electric locking effected by the approach of a train, actuating a track circuit relay or a track instrument. It is used to protect a train approaching an interlocking plant at which the signals have been cleared for its passage over the route lined up. After a train passes over a plant the route is released automatically.

Approach locking is generally used at points where trains pass at high speed, but it can be applied also to other than high speed routes where conditions may require. The arrangement of the locking is such that with the route once lined up the levers are locked as soon as the train approaches the signals; that is, while it is yet as far as one or two miles away. If an approaching train locks switches and derails by this means, and then is stopped or detained and does not use the route, the leverman can unlock his levers by closing an unlocking circuit by means of a "time release." The releasing device is arranged to enforce deliberation (and thus prevent errors) by an automatic time device; by a slow-moving circuit closer operated by making a number of turns of a screw; or by a hand switch fixed in a remote position requiring some time for the leverman to get to it. Thus the leverman will be prevented from taking away hastily a route which has been set up for an approaching train. Approach locking may be used only for one or two movements through an interlocking plant, or it may be expanded to cover any movement, and was adopted as a check on the leverman to prevent him changing a route carelessly after it had been lined up and accepted by the engineman. This locking does not prevent signals being placed in the normal position, but it does prevent the switches or derails being changed until after a train has passed the home signal, unless these functions are unlocked by the time release mentioned above. The interval necessary to accomplish the release is sufficient to permit a high speed

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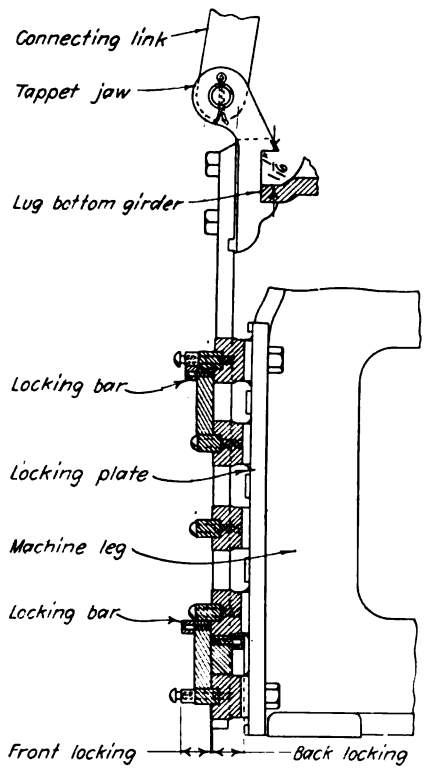
train to traverse the plant or to be stopped by the normally placed signal. See Release, Screw. Also Locking, Electric. Also Release, Time. Also Indicator, Approach.

LOCKING, BACK. The mechanical locking in a Standard (or, as sometimes called, Style A) interlocking machine which acts in the same plane as the tappets.

Each space of the locking bed accommodates two tiers of locking, the back locking and the front locking. It is possible to place three locking bars side by side, in the space provided for the back locking



Section of a Standard Mechanical Interlocking Machine Showing Front and Back Locking and Other Parts

bars and five bars side by side in the front locking space.

The function of back locking in connection with front locking, is to interlock mechanically levers controlling conflicting routes. Back locking consists of locking dogs and locking bars actuated by a tappet operated by the lever in the machine. The locking bed is vertical and the back locking is the tier of locking on the back side of the bed as a person faces the front of the machine. The mechanical construction of the locking is that of a bar or tappet moving in a vertical plane, locked by dogs moving at right angles to it and fitting in notches cut in the edge of the tappet. The dogs consist of tapered pieces of steel. Back locking is also a term sometimes applied to normal indication locking in connection with electric locking. See Locking, Front. Also Locking, Indication.

LOCKING BAR. (1) A bar running lengthwise in the interlocking machine, to which the locking dogs are attached. (2) A British term for a detector bar. See Locking.

LOCKING BED. That part of an interlocking machine which contains or holds the tappets, locking bars, cross locking, dogs, etc., used to interlock the levers controlling conflicting movements. See Locking.

LOCKING, CHECK. A method of electrically interlocking the levers in two adjacent interlocking plants to permit train movements to be made against the current of traffic.

Where two interlocking plants are situated close together as in terminals and at tunnel, bridge or yard locations, and each has signals governing in the direction of the other on the same track, it is necessary to provide some means to prevent any two such opposing signals being cleared at the same time. This condition in one plant only is cared for by the mechanical locking in the interlocking machine, but when two plants are involved the provision must be electrical. In electric and electro-pneumatic interlocking plants a separate lever is usually provided in the interlocking machine in each tower for each track over which reverse movements are to be made. These levers are connected with the mechanical locking in such a way that when they are in their normal positions the signal for reverse movements is locked in the stop position and the signal governing movements with the current of traffic is free to be moved. When check lock levers in both towers are reversed, the signal for normal movements is mechanically locked in the stop position and the dwarf or other signal for reverse movements at the adjacent interlocking is unlocked to allow reverse movements.

The use of check locking adds additional flexibility to routes, and in terminal districts facilitates the movements of a large number of trains with safety, while operating over a minimum number of tracks. Check locking used in connection with two or more tracks is generally applied to give preference as to the direction of traffic, while on single track lines as at tunnels, bridges, etc., no preference of direction exists and the check locking practically performs the function of a controlled manual block between the two plants. The application of check locking must be effective when a signal governing the stretch of track between the plants is cleared for a train movement and remain in effect while the train occupies this track. It can be made effective for train operation in one or in both directions. Check lock levers are sometimes referred to as traffic levers or master levers. See Locking, Electric.

LOCKING, CROSS. The transverse locking bar in an Improved Saxby and Farmer interlocking machine which is moved by the locking dog attached to the longitudinal locking bar. See Locking, Mechanical.

LOCKING, DETECTOR. See Locking, Section.

LOCKING DOG. A variously shaped tapered steel block attached to a locking bar, through which the interlocking of the various levers in an interlocking machine is accomplished. See Locking. Also Locking, Back.

LOCKING, ELECTRIC. The locking of the levers of an interlocking machine or of switches or drawbridges by electric locks to insure the integrity

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of a route, or portion of a route, during the movement of a train over it.

Electric locking is accomplished by controlling the current for operating the locks or other apparatus by track circuit relays or track instruments, or by circuit controllers actuated by signals, switches, drawbridges, etc. It is used as a safeguard against possible mistakes of levermen, such as changing the positions of signals, derails and switches ahead of trains. Train operating conditions require that various schemes be employed to meet the requirements, and electric locking may be classified under different headings, as: Approach locking; section locking; route locking; sectional route locking; indication locking; stick locking; check locking; electric or outlying switch locking; and bridge locking.

Approach locking, which is installed to prevent a leverman changing a route which has been accepted by an engineman, is so arranged that it becomes operative as soon as a distant or a home signal is cleared or a train enters a track section from one-half mile to a mile in advance of the distant signal. The signal may be placed in its normal position but the route cannot be changed until the train has passed the home signal.

Section locking is arranged to prevent a switch being thrown under a train, this being accomplished through the medium of the track circuit. The circuit in which the switch is located is shunted by the train, thus locking the lever in the correct position. This locking method is used in connection with or in place of a detector bar.

Route locking is an extension of section locking to include the fouling points on a track and to lock switches in advance of a moving train.

Sectional route locking constitutes a further refinement for while route locking is satisfactory from a safety standpoint, from an operating standpoint it does not allow traffic to be handled rapidly at busy signal plants. Sectional route locking permits a switch to be unlocked after a train has passed it and is arranged to allow the locking to take effect in whatever direction the train is moving.

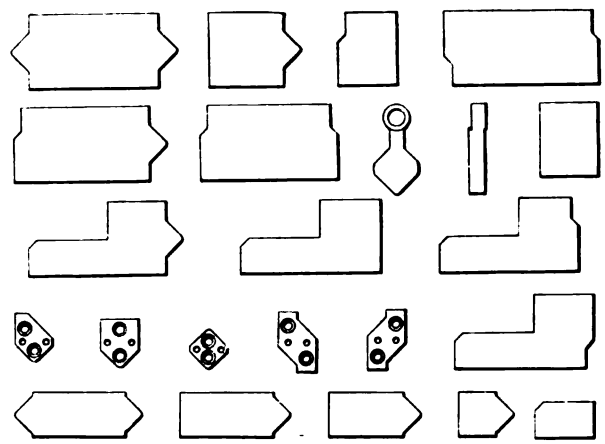
Indication locking is an outgrowth of the power plant and is used to insure that the position of the operated unit and the lever in the machine correspond. Stick locking is similar to approach locking in that it provides the same protection, but unlike approach locking it locks the route when once the home signal is cleared, regardless of the approach of a train. Check locking is electric locking provided between two interlocking plants to prevent the clearing of conflicting signals governing train movements over the same track.

Electric or outlying switch locking is electric locking sometimes provided for switches located too far from a tower to be handled from the machine, but which should not be moved without the knowledge and consent of the leverman.

Bridge locking is employed in connection with movable bridges, to prevent signals governing the approach to the bridge being cleared unless the bridge is locked in its closed position.

Devices used in connection with electric locking are track instruments, interlocking and stick relays, approach indicators, annunciators, screw releases, tower indicators, time locks, floor pushes, emergency switches, lever locks, time releases and similar apparatus. See Locking, Approach. Also Locking, Route. Also Locking, Sectional Route. Also Locking, Indication. Also Locking, Stick. Also Locking, Section. Also Locking, Check. Also Lock, Outlying Switch. Also Unit (Operated). Also Indicator, Approach.

LOCKING, FRONT. The mechanical locking in a Standard (Style A) interlocking machine which acts in a plane outside the tappets. Its function in connection with the back locking is to interlock mechanically levers controlling conflicting routes. The front locking is the tier of locking on the front side of the locking bed and is operated in the same



Typical Locking Dogs for a Standard Interlocking Machine

manner as is the back locking. It also has the same characteristics, except that in the case of the front locking, small lugs known as tappet pieces are fastened to the tappets (as the locking is outside the plane of the tappets) and the locking dogs strike against these as they would against the side of the notch in the tappet in back locking. See Locking, Back.

LOCKING, HORIZONTAL. See Locking, Mechanical.

LOCKING, INDICATION. Electric locking designed to function if a switch, signal or other operating device should fail to make a movement corresponding with that of the operating lever.

This locking is of great importance in connection with power-operated units because, unlike mechanically-operated units where the leverman can tell the condition of the function from the feel or pull of the lever, a leverman operating a lever in a power machine or a lever in a mechanical machine electrically controlling power operated signals, simply makes and breaks electric contacts and has no indication of the position of the function if indication locking is not provided. This locking prevents the manipulation of levers which would bring about an unsafe condition due to the operated device failing to respond to the lever movement and it will prevent the operation of a unit in case another function which should be operated first fails to complete or make its movement.

This locking is designed to function for signals on returning signal levers to the normal position,

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for while if a signal should fail to clear, a delay results; if a signal should fail to go to the stop or caution position after clearing, and no such locking was in effect the mechanical locking in the machine would release the route, allowing a conflicting route to be set up, thus producing a very dangerous condition. Should a clear failure occur this locking prevents the signal lever being placed in the full normal position, thus preventing the release of the mechanical locking.

The application of this locking to a switch is made to both the normal and reverse positions of the lever, as it is essential to know that the switch has assumed and is locked in either the normal or the reverse position corresponding to the positions of the levers. Thus the clearing of a signal governing a switch or the setting up of a conflicting route is prevented unless the switch is in its proper position for such a move to be made. Indication locking is used in connection with power-operated units on mechanical and electro-mechanical plants. See Locking, Electric. Also Indication. Also Signal, Power Operated. Also Unit (Operated).

LOCKING, LATCH. The interlocking of one lever with another by means of the latches of the levers.

This arrangement is necessary in mechanical interlocking to effect preliminary locking. In grasping a lever preparatory to moving it the leverman unlatches it, and in so doing locks all conflicting levers before his lever moves. Other levers intended to be released after this lever movement is effected are interlocked by the return of the latch to its notch after the lever has completed its stroke. For example, a lever in an Improved Saxby and Farmer machine is held in position until the latch rod foot is raised above the quadrant, by raising the latch handle. Through the rocker and locking shaft, the latch handle movement imparts one-half of the full throw to the longitudinal locking. This in turn gives the full throw to the cross locking and locks all conflicting levers which were unlocked before. It also keeps locked all levers that should remain locked until the lever is moved to its opposite position and the latch rod foot has been lowered and engaged by the stop on the quadrant. This holds the lever in position and completes the other half throw of the longitudinal locking. It readily can be understood that throwing the lever does not transmit any motion to the locking and that it is impossible to release a lever which should not be thrown because the latch cannot be raised. As very little power can be applied to the latch handle because of the slight leverage employed, the strain in the locking is small, which would not be the case if the locking were driven directly by the lever. See Locking. Also Locking, Preliminary.

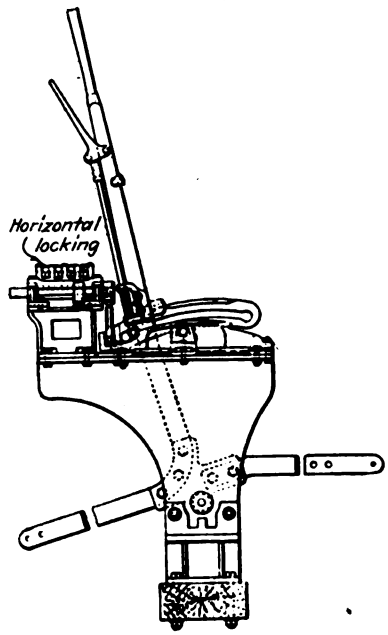
LOCKING, LEVER. The locking of interlocking switch and signal levers by the movement of levers, as distinguished from latch locking. See Locking. Also Locking, Latch.

LOCKING, LONGITUDINAL. That part of the mechanical locking apparatus which extends longitudinally in the locking frame. See Locking.

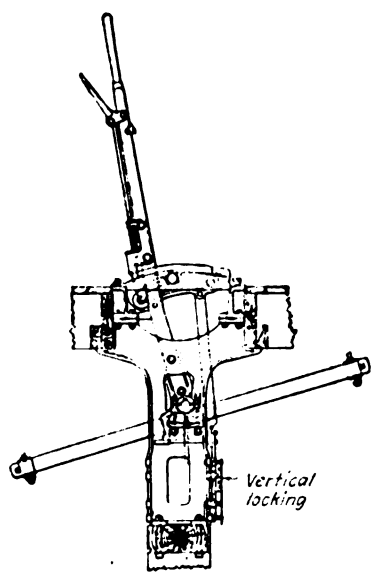
LOCKING, MECHANICAL. The arrangement of rods, bars, dogs, tappets and other apparatus in an interlocking machine, designed to prevent a leverman from throwing switches and signals for conflicting train movements, thus preventing him from causing an accident.

The concentration of a considerable number of switch or signal levers in the control of one man naturally creates a possibility that the leverman may at some time mistake the lever which he is to throw and thus cause a train accident. To prevent such mistakes the various levers placed together in one bank or frame are so interconnected by the locking that only proper and non-conflicting movements can be made.

Mechanical locking is of two general types, horizontal and vertical, the horizontal type, as arranged on the Improved Saxby & Farmer machine, being the more generally used. In this type the locking is made operative by the movement of the latch handle, which motion is transmitted to the locking bars through a rocker and a locking shaft.



Saxby & Farmer Mechanical Interlocking Machine Showing Horizontal Locking



Interlocking Machine Showing Vertical Locking

Vertical locking is employed in the Standard (or Style A), the Johnson and the National machines. On the Standard machine the leverman, on raising the latch handle, raises the latch rod and latch block which release the levers and at the same time give the rocker one-half its throw, which is transmitted through the connecting link to the tappet and locking. When the lever is reversed the tappet moves upward instead of downward, and the rocker is attached to a bracket which is connected rigidly to the lever.

The mechanical locking used on power-interlocking machines is also of either the horizontal or ver-

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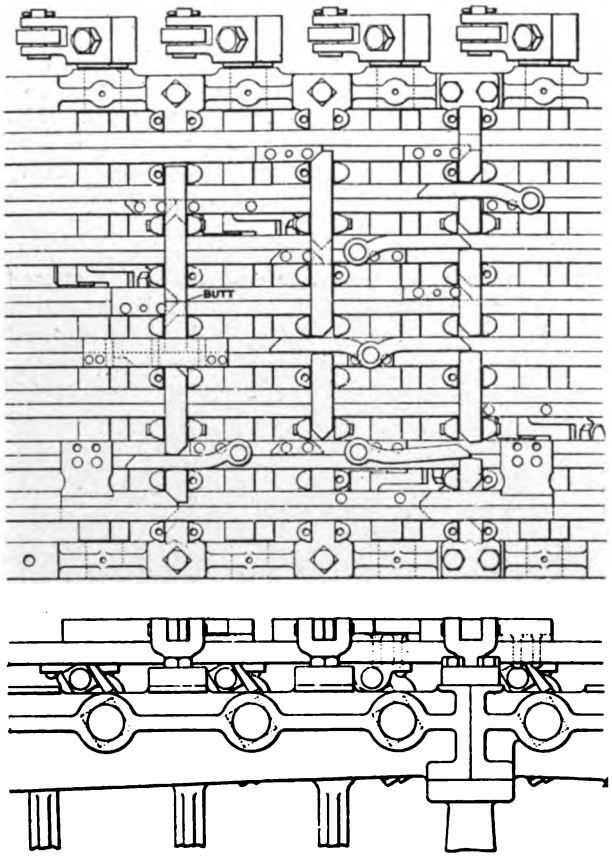
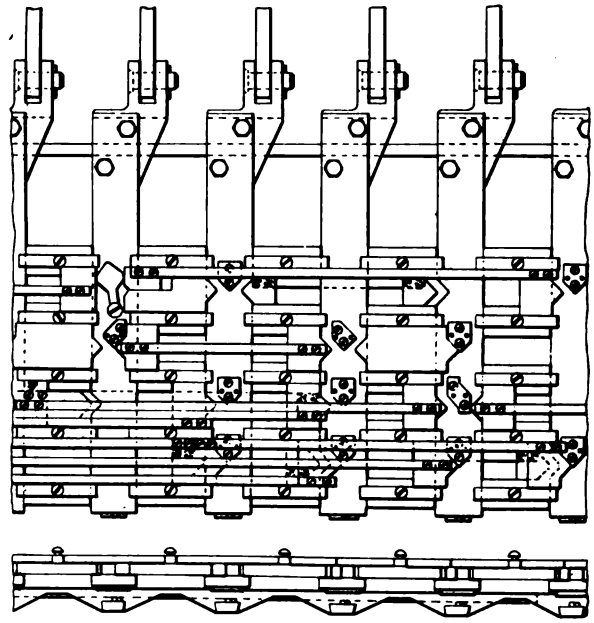
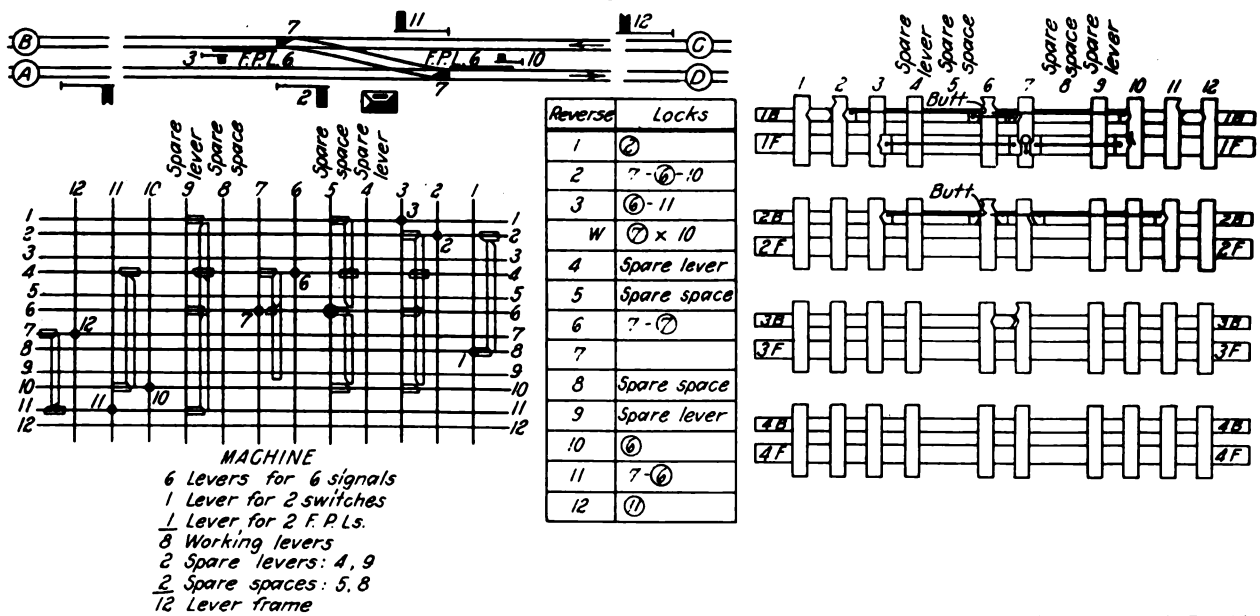
tical type. In the latter type the different levers are interlocked by means of vertical locking similar in design to that on the Standard (Style A) mechanical machine but reduced in size and, in proportion to the number of levers, occupying but a small amount of floor space in the tower. It is also arranged to take four bars in each groove of the locking plates instead of three as in the mechanical machine. The locking used in another design of power machine is a miniature Improved Saxby and Farmer type of horizontal locking, being one-fourth the size used in the mechanical machines. Another design includes a miniature lever, rocker and quadrant similar to that on the I. S. & F. machine, to operate a tappet and locking reduced in size but similar to the back locking on a Standard mechanical machine except that the locking bed is placed in a horizontal instead of a vertical plane. In this design, locking bars can be used in each groove of the locking plates which are of seven way, three being the maximum number that can be used, giving a total of 23 spaces for locking bars. The mechanical locking employed on still another type of power machine is of the vertical type of tappet locking arranged in a vertical locking bed



Section of Horizontal Locking Bed for I. S. & F. Interlocking Machine



Section of Standard Mechanical Interlocking Machine Showing Mechanical Locking



Reverse	Locks
1	②
2	7-⑥-10
3	⑥-11
W	⑦ × 10
4	Spare lever
5	Spare space
6	7-⑦
7	
8	Spare space
9	Spare lever
10	⑥
11	7-⑥
12	⑪

Mechanical Locking of Improved Saxby & Farmer and Standard Interlocking Machine, Showing Plan of Double Track with Crossover and Locking Sheet

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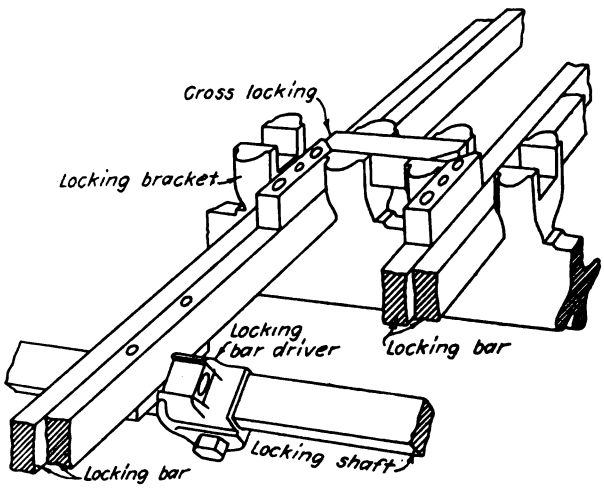
on the front of the machine. All but one design of power machines are of the lever locking type as compared to the latch locking used for mechanical machines.

Some of the R. S. A. requirements for mechanical locking are that it shall be of the preliminary type; for each lever and each space, depending upon the



Locking Bars and Cross Locking of Saxby & Farmer Interlocking Machine

type of the machine, provision shall be made in the locking bed for space to accommodate either:

(1) One locking shaft with one cross locking bar and one longitudinal locking bar for the full length of the machine.

(2) One tappet with one longitudinal locking bar for the full length of the machine. The locking shall be distributed as uniformly as possible in the locking bed and arranged to be easily accessible. See Locking, Latch. Also Locking, Back. Also Locking, Front. Also Locking, Preliminary.

LOCKING, PRELIMINARY. Interlocking so arranged that the locking of a lever, to prevent it from being moved in conflict with another lever which is about to be moved, is fully effected before the second lever begins to perform its function.

In mechanical interlocking this is accomplished by means of latch locking by the movement of the latches of the levers which, on being unlatched, lock all conflicting levers before the proposed lever can be moved. Levers intended to be released after this lever movement is effected are unlocked by the return of the latch to its notch in its new position after the lever has completed its stroke. In power machines it is not necessary to have large levers as these are not required to operate the switches and signals directly. Therefore, the preliminary locking may be accomplished by the first and the last part of the lever movement as it, by a single stroke, does three things: (1) locks conflicting levers; (2) performs its own main function (causing the movement of a switch or signal); (3) unlocks other levers which may then properly be moved. See Locking, Mechanical. Also Locking, Latch.

LOCKING, ROUTE. Electric locking arranged to become effective when a train passes a signal and to prevent levers being operated which would endanger the train movement over the route lined up.

The purpose of route locking is to prevent a leverman lining up an intersecting or conflicting route before a train has completed its movement over the first route lined up, as such action might result in a derailment or collision. Switches, drawbridges, etc. in a route, or the signals of a conflicting route may be locked up. Route locking may be made to take effect upon the clearing of the signal governing the route, after which the route locking maintains the integrity of the route until a train has passed over it. See Locking, Electric.

LOCKING, SECTION. Electric locking which is effective when a train occupies a certain section of a given route.

This is accomplished by the use of track circuits and relays for controlling electric locks on the switch or signal levers of an interlocking machine, or opening the controlling circuits of switches to prevent switches from being thrown under cars, a function originally performed by a detector bar. Section locking is usually extended to the fouling points of the switch controlled, and may be used instead of or in addition to detector bars. This locking is sometimes called electric detection or detector locking. See Locking, Electric.

LOCKING, SECTIONAL ROUTE. Electric locking of the route-locking type, so arranged that the locking for each section of a route is released as a train, in passing over the route, clears each section.

This locking may be considered as a combination of section locking and route locking. The route locking locks up any particular route when the train using it passes the governing signal. By the use of the sectional locking each section is released as the rear of the train passes that section. This type of locking is employed mostly at large terminals and yards where heavy and congested traffic occurs as the unlocking of the switches in a route behind a train permits other routes to be set up rapidly and allows the maximum number of trains to be handled with safety without the use of a large number of signals. See Locking, Section. Also Locking, Route. Also Locking, Electric.

LOCKING SHEET. A statement in tabular form of the locking operations provided in a given interlocking machine, showing the sequence in which levers must be locked or unlocked preparatory to giving clear signals for each route in the plant.

The locking sheet is made up as a guide to the preparation of the dog chart. In order to understand the relation existing between the locking sheet, the dog chart and the track layout it is necessary to consider the manner in which the interlocking of the levers is accomplished. The different units are so connected that when the leverman is operating levers at one end of the machine, the operated units are located at the corresponding end of the interlocking plant. The position of the machine in the tower should first be determined. This is designated in the track diagram in the tower plan by a heavy black line, while a dot represents the position of the leverman. Numbers are then assigned to the levers controlling the various units. It is the practice to number the high signals first, then the dwarf signals for movements in one direction; then part of the spare spaces or levers, if any; then the switches, derails

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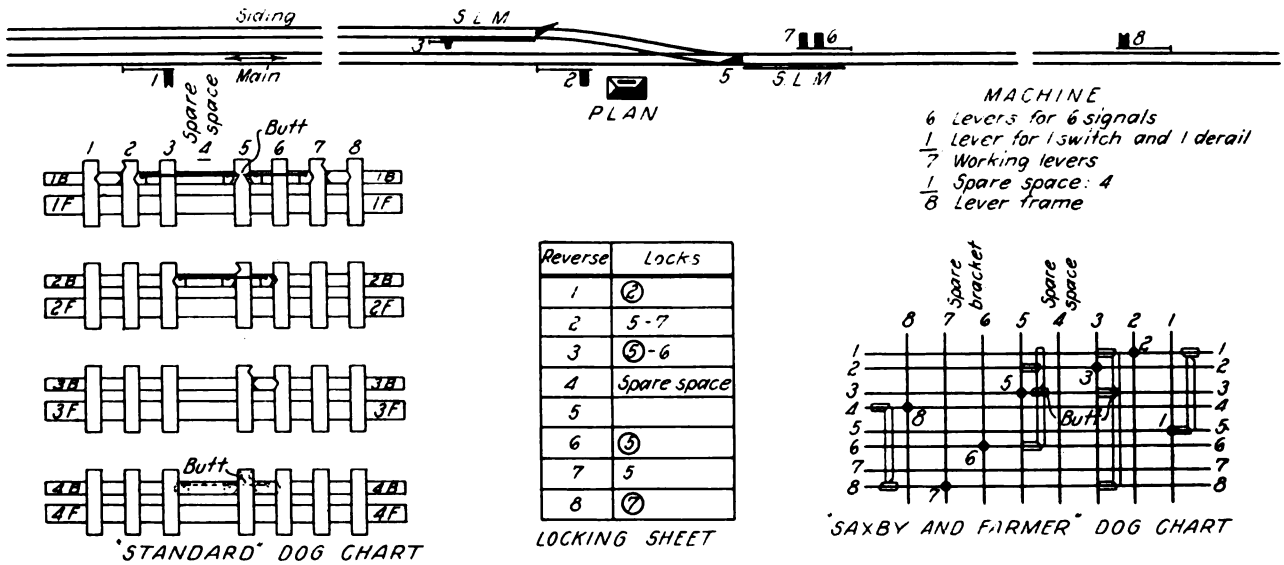
and facing point locks; then the remaining spare spaces or levers; and finally the signals for movements in the opposite direction, the numbers running from left to right as the leverman faces the machine. However, in order to save the time of the leverman in going from one end of a large machine to the other in setting up routes the levers for a particular route are frequently grouped together, the various levers required for the route still being numbered as indicated above.

Before proceeding to make the locking sheet, the routing of the various signals must be determined. A circle around a figure on the locking sheet represents that lever as in its reversed position. Thus on the sheet illustrated it is seen that reversing lever No. 1 should lock lever No. 2 reversed, while lever No. 3 (dwarf signal) reversed (or cleared) locks switch No. 5 reversed and the opposing signal No. 6 which governs a train movement into the siding. On complicated layouts the locking sheet naturally is complicated as conditions arise when a lever in its normal position in one combination will allow certain locking to be effective but when in the reversed position another combination can be set up, etc. See Dog Chart. Also Interlocking. Also Interlocking, Machine. Also Locking, Mechanical.



Interlocking Plan, Locking Sheet and Dog Charts, Single Track and Turnout

LOCKING, STICK. Electric locking which becomes effective on the clearing of a signal and which is released by the passage of a train. It is designed to prevent an operation of the levers which might produce a dangerous condition for an approaching train. The name is derived from the use of a stick relay which is usually one of the essential features of this type of locking.

Stick locking is very similar to approach locking and is arranged to provide the same protection. With high speed trains, requiring the distant signal to be at a considerable distance from the home signal, if some such locking was not provided it would be possible for a leverman to change the route after an engineman had accepted the distant signal indication with the possible consequences of a collision or derailment. In this type of locking if the signals are cleared the locking is effective and if a train does not accept the signal it is necessary to operate some form of release to unlock the route and restore the signals to normal. It locks the route once set whether a train is approaching or not. This is not true of approach locking. See Locking, Approach. Also Locking, Electric.

LOCKING, VERTICAL. See Locking, Mechanical. Also Locking, Back.

N

NORMAL. A term applied in signaling to the customary position of a switch, interlocking lever, signal, derail or the usual movement of trains on a given track. The position in which a lever in an interlocking machine stands when the corresponding switch or signal or other unit is in its normal position.

A switch is normal when set for the main track; a derailing switch is normal when set to derail; a home signal when it indicates stop; a distant signal when it indicates caution. Automatic block signals in their simplest form are called normal clear, as at all times when their block sections are unoccupied with the switches closed and all apparatus in order the home signals stand at clear, thus indicating proceed.

In a modified arrangement called "normal danger," the home signals indicate "stop" at all times (even when the block is clear), except when a train is approaching and they then indicate "proceed" only in case the block ahead is clear. The practice thus resembles that in manual signaling where home signals are kept in the stop position except when it is necessary to clear them for the passage of a train. On a railway with more than one main track the normal movement of trains on a given track is in the direction in which trains regularly travel on that track, and they may be moved in the opposite direction against the "current of traffic" only by special order of the train dispatcher, or by signal indication if the track or tracks are signaled for train movements in both directions.

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NORMAL CLEAR. An expression applied to a system of signals in which the signals normally stand at or indicate "proceed" whether a train is approaching or not. See Normal Danger. Also Block Signal System, Automatic.

NORMAL DANGER. The expression applied to a signal system in which the signals are normally in the "stop" position, the signals being cleared by a train in advance of its approach, providing the block ahead is clear. See Normal Clear. Also Block Signal System, Automatic.

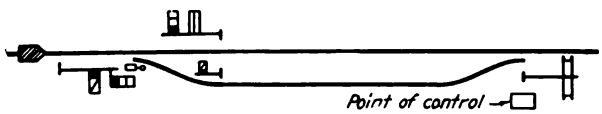
O

OHM. The unit of electrical resistance.

Since a force is necessary to send electricity along a path it is clear that there must be something present which opposes the passage of electric current and this opposition has been given the name of resistance. As with electromotive force, resistance is also variable and its unit of measurement is the ohm. This unit is such a resistance as will limit the flow of electric current to one ampere under an electromotive force of one volt. The standard measure is the resistance of a column of pure mercury one square millimeter in cross-section and 106 centimeters long at a temperature of 0 deg. C, or 32 deg. F. See Ampere. Also Electromotive Force. Also Volt.

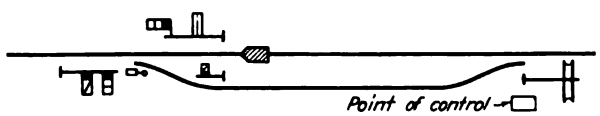
OUTLYING SWITCH CONTROL. A system of operation of isolated switches and signals through the medium of power-operated mechanisms, the switches and signals being either immediately adjacent to or at a distance from the point where the control is to be exercised.

Outlying switch control is used to advantage at such locations as switches on single or double track



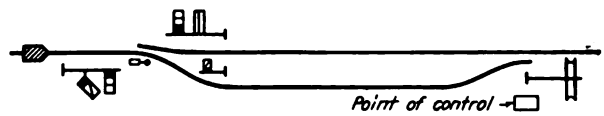
One End of Passing Track on Single Track, Train Proceeding on Main Line

located at some distance from a station; at the end of double track and at junctions and entrances to yards where the operator or other attendant at a nearby station can control the position of the switches in such a way as to allow trains to enter or leave sidings or yards and to turn out at junctions with-



One End of Passing Track on Single Track, Train Proceeding on Main Line

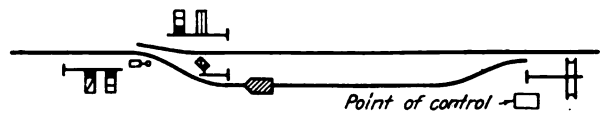
out stopping or reducing speeds below those safe for passing through. Among the advantages of this form of switch operation is an increase in safety of traffic; the elimination of train stops, thereby decreasing operating expenses by saving in fuel, wear and tear of brake and other equipment and in time of trainmen; and trains may be kept moving under the direction of the dispatcher without stopping for orders. In manual block territory a train may occupy the main track between the block signal and the signals of the outlying switch, thus subdividing the block and allowing an opposing move to be made



One End of Passing Track on Single Track, Train Proceeding from Maine Line to Siding

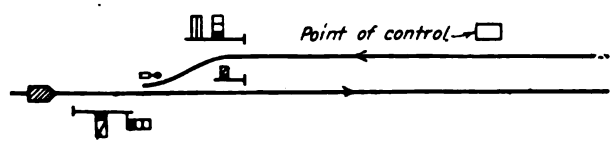
from the next block office without the use of a clearance.

Such installations are generally applied to manually-operated switches used most frequently; switches



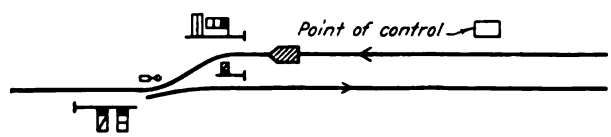
One End of Passing Track on Single Track, Train Proceeding from Siding to Main Line

located on grades or curves where difficulty is experienced in starting trains after stopping or slowing down and on stretches of track where traffic is particularly dense. Installations are usually made



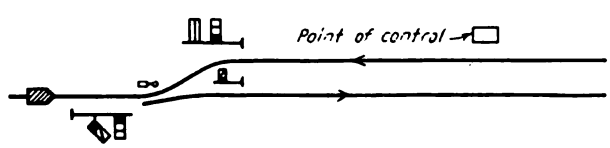
End of Double Track

with low voltage electric switch and signal mechanisms operated by a 20-volt primary or storage battery. Switch parts are prevented from being moved while engines or cars are on or adjacent to the switch



End of Double Track, Train Proceeding from Double to Single Track

through the medium of electric track circuit control. Signals may be made to control train movements over the switch and provide additional safety in that a train taking sidings must have passed the fouling



End of Double Track, Train Proceeding to Double Track Against Traffic

point before another train can get an indication to proceed on the main track.

The apparatus required for outlying switch con-

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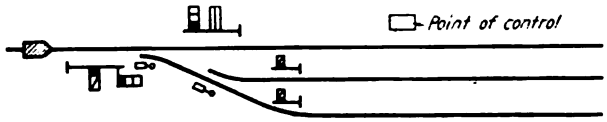
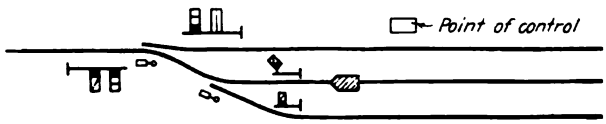
trol is similar to that used in other signaling and interlocking and can be operated in conjunction with a manual or automatic block system, electric, elec-



Yard Entrance, Train Proceeding on Main Track

tro-pneumatic and electro-mechanical interlockings. Different methods are employed for controlling and operating outlying switches, no one of which can



Yard Entrance, Train Entering Main Track from Yard

be accepted as best adapted to all locations, for traffic requirements will determine the scheme best suited to particular conditions.

OVERLAP. An arrangement of track circuits for block signals originally introduced as a substitute for distant signals. With a block section extending from A to B a track circuit for, say 2,000 ft. beyond B is arranged, so that when this space is occupied by a train (or car) the signal at A will be held in the stop position the same as though the train were between A and B. Thus when signal A is cleared, an engineman accepting this signal knows no train is in the 2,000 ft. track circuit in advance of Signal B. Where a line is fully equipped with distant signals, so that enginemen will never need to slacken speed to make sure of the indication of the home signal before passing it, the overlap is generally deemed unnecessary. In one scheme of single track automatic block signaling overlaps are used to prevent a collision between trains moving toward each other, which, without the overlaps, might pass clear signals at the same moment. The opposing signals are so situated that each train will encounter a stop signal before it can meet the other in a butting collision.

In double track signaling a full block overlap is sometimes used in which case a train sets two stop signals and a caution signal behind it.

With reference to overlaps in connection with automatic signal systems, the Railway Signal Association has stated that (1) overlaps are undesirable for the following movement; as adequate information can be provided in the signal system, (2) overlaps are necessary for opposing movements where adequate advance information cannot otherwise be provided. See Block Signal System, Automatic.

P

PERMEABILITY. A term used to express the ability of a substance, such as iron or steel, to carry magnetic lines of force.

As there is no name for the unit of permeability a comparison is made between a certain specimen of iron or steel and air which is considered to have a permeability of one. The permeability of any materal may be found by comparing its flux density to that produced in air. Thus a piece of iron is said to have a permeability of 1,250 which means that its permeability is 1,250 times greater than air. As in reluctance, permeability is variable. With the increase in flux in a magnetic circuit the reluctance increases while the permeability decreases; that is, as the number of lines of force increase through a piece of iron or steel, its ability to accommodate additional magnetic lines is decreased. Permeability expressed mathematically is the ratio between the number of lines of force produced in a magnetic circuit consisting of iron or steel, and the number of lines of force produced by the same number of ampere turns, but having nothing but air in the magnetic path. For example, if a solenoid without an iron core produces 10 lines of force with a given current flowing in the windings, and the same solenoid produces 20,000 lines of force with the same current when an iron core is placed within it, the permeability of the iron would be 20,000 divided by 10 or 2,000. See Lines of Force. Also Ampere Turn.

PERMISSIVE CARD. A form which, when filled out by a block operator, authorizes a train to enter a block already occupied by a train proceeding in the same direction.

This form has been adopted as a standard by the A. R. A. and incorporated in its Standard Code. It is printed on pink paper to distinguish it from the clearance and caution cards.

The rules governing the issuance of this card state that a train must not be admitted to a block which is occupied by an opposing train or by a passenger train except as provided for by Rule 332 or by train order. To permit a train to follow a train other than a passenger train into a block the block operator must give the communication code to "display stop signal, train following" to the next block station in advance; while block operator receiving the signal, if there is no passenger train in the block, must reply "Block is not clear of train other than passenger, I understand." The approaching train is then admitted to the block under a permissive signal or with permissive card (Form C).

A permissive signal or a permissive card (Form C) must be used to permit a train to use crossover switches and this only after the block is clear and arrangements have been made with the block operator at the next block station in each direction to protect the movement. All crossover movements must be entered on the block sheet. See Caution Card. Also Clearance Card. Also Block System, Manual.

PHASE. (Electric) A term used in connection with the electromotive force produced by an alter-

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nating generator. When used in connection with a generator it designates the number of circuits in the armature. For example, a single phase generator has one circuit in its armature while a two-phase machine has two circuits which generate two e. m. f's. at 90 electrical degrees apart. In the three-phase machine three e. m. f's. are generated, each 120 electrical degrees apart. See Alternating Current.

PIPE LINE. A length of pipe (or rodding), forming a connection between an operating mechanism and the unit to be operated. The operating mechanism may be a lever in an interlocking machine, a ground lever at an outlying switch, a switch stand, etc., used to throw a switch, derail, facing point lock, signal bridge coupler or lock, wing or point frogs, etc.

The pipe used in the down rods on a leadout should be of 1½ in. steel or wrought iron pipe fitted with 1¼ in. jaws for the connection between the cranks, deflecting bars or rocker shaft and the machine lever. The pipe line outside of an interlocking tower consists of 1 in. steel or wrought iron pipe except under tracks or in similar places where brine drippings or other adverse conditions make a solid connection necessary when 1½ in. solid iron rodding should be used.

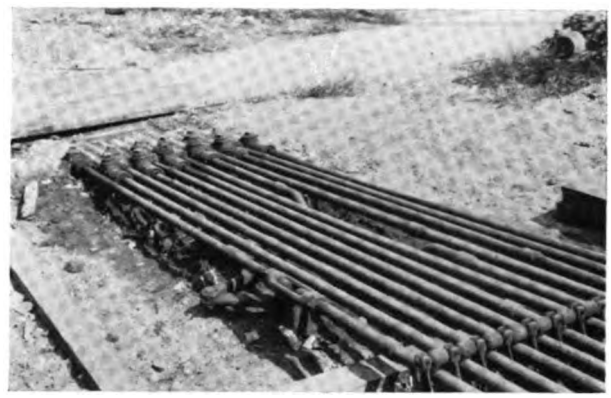
Pipe lines are spaced 2¾ in. apart and are supported on pipe carriers located not more than 8 ft.

Leadout and Pipe Lines at Mechanical Interlocking, Showing Pipe Carriers and Foundations

apart center to center on tangents and not more than 7 ft. apart around curves of 2 deg. or sharper while the pipe nearest to the track (at an interlocking plant) should not be less than 4 ft. 6 in. from the gage line of the nearest rail. On draw bridges and approaches it is often impossible to maintain this distance and under such conditions the pipe lines should be as far from the gage line as the conditions permit.

Pipes should be arranged where practicable in main pipe line runs so that they lead off on the track side in regular order to prevent one pipe in the cross run crossing over or under one or more pipes to the unit it operates. It is desirable to locate cranks and compensators in the main pipe run so that the field side is left clear for trunking and additions to the pipe line. No couplings in a pipe line should be nearer than 12 in. from the pipe carriers when the lever in the interlocking machine is placed in the center position of its stroke, for otherwise it might strike a pipe carrier, preventing the proper operation of a unit.

Pipe lines running under tracks should be so arranged as to permit ties to be spaced the standard distance and to allow for their proper tamping. In many cases I beam track supports are used in place of ties where pipes pass under a track. Transverse pipe carriers are used to support pipes running under tracks, when these carriers are supported by ties they



Oil Pipe and Stuffing Boxes in Pipe Line at Mechanical Interlocking, Showing also Adjusting Screw, Compensator and Carriers

are fastened to them with two ¾-in. by 4-in. lag screws, but when supported by I beams they should be bolted to them. In many locations, such as under streets, it is often necessary to run the pipe line under ground in which case the 1-in. pipe is encased in 2-in. galvanized iron pipe, preferably provided at each end with a stuffing box, and the 2-in. pipe is then filled with a non-freezing oil. However, some roads do not use stuffing boxes and oil, prefering to leave the ends open, and the center of the pipes higher in order to provide proper drainage for any water that may collect in them. In some cases roads encase the entire length of 2-in. pipe in concrete, while other roads use concrete end blocks for support only.

Pipe lines are carried on concrete pipe carrier foundations 8 in. by 12 in. and either 2 ft. or 3 ft. long. To the tops of the foundations are bolted pipe carrier tops of either metal or wood for the support of the pipe carriers. Where conditions permit the tops of the pipe carrier foundations in the main pipe line runs are placed ⅛ in. below the base of the rail. When it is necessary to make an offset in a pipe line it must be made in the body of the jaws or in an iron rod 1½ in. in diameter placed in the pipe line for that purpose and the total offset between any two supports must never exceed 3½ in. The minimum distance between the ends of an offset should be not less than twice the amount of the offset while offsets in cranks and compensators should be avoided as much as possible.

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When it is necessary to make turns in pipe lines with radial arms, cranks or deflecting bars the R. S. A. recommends the following:

Angle of Deflection in Degrees	Deflecting Bars	Radius
0 to 11	with tang ends	..
11 to 33½	22½ deg. with eye ends	72 in.
33¾ to 56	45 " " " "	36 in.
56 to 78½	67½ " " " "	24 in.
78¾ to 90	90 " " " "	18 in.

Radial Arms and Cranks

0 to 30	15 deg. radial arm cranks
30 to 75	60 deg. acute angle cranks
75 to 105	90 deg. right angle cranks
105 to 140	120 deg. obtuse angle cranks
140 to 180	180 deg. equalizing arms

Deflecting bars should not be used at any point where the total movement of pipe line due to stroke expansion and contraction is more than 11 in.

SPECIFICATIONS FOR ONE-INCH SOFT STEEL SIGNAL PIPE

1. **Pipe.** (a) Pipe must be of soft steel, straight, tough and uniform in quality; free from cinder pockets, blisters, burns and other injurious flaws. It must be hot galvanized inside and outside, unwiped.

(b) The tensile strength, limit of elasticity and ductility shall be determined from a test piece cut from the finished pipe.

(c) The pipe shall have a tensile strength of not less than 52,000 lb. per sq. in., an elastic limit of not less than 30,000 lb. per sq. in., and an elongation of not less than 18 per cent. in a measured length of 8 in. Pipe must stand a test of 600 lb. per sq. in. internal hydrostatic pressure without leak.

Some of the Fittings Adjacent to Operated Units at Mechanical Interlocking

(d) A piece of pipe 1 ft. long will be selected at random and be subjected to a flattening test by hammering the piece until the opposite sides are within twice the thickness of the wall from each other; the piece shall show no cracks in the steel except at the weld.

(e) The weight of 1 ft. of 1-in. pipe before galvanizing should be 1.71 lb., and in no case will pipe be accepted weighing less than 1.63 lb. per ft., weight of plug and coupling not included.

(f) The outside diameter of pipe must conform to Brigg's standard. Any pipe enough less than 1.31 in. in diameter to result in flat thread, will be rejected.

(g) The manufacturer shall furnish all necessary facilities for making tests and the tests shall be made at the mill.

(h) Inside diameter of all pipe must be large enough to receive a hardened steel plug of 63/64 in. diameter for a length of 6 in.

(i) Not more than 1 per cent of pipe less than 15 ft. long will be accepted, lengths of 17 ft. and over preferred.

(j) Ends of pipe must be cut square and drilled for two ¼-in. rivets on one end only; the first rivet hole shall be drilled 2 in. from the end and the second, 2 in. from this and at right angles to it.

(k) Each length of pipe shall have a thread 1⅛ in. long, with a ⅜-in. total taper per ft., and 11½ slightly rounded top and bottom "V" threads to the inch. The threaded portion of the pipe shall be of such diameter as to admit the coupling to be screwed on 5 turns by hand, with a permissible variation of one turn either way.

2. **Couplings.** Pipe couplings must be galvanized, must be 2¼ in. long and 1¾ in. outside diameter, of wrought iron, free from defects, faced at ends, tapped straight through, pitch diameter of thread to be such as to fit pipe as per section (1), paragraph (k), 1.26 in. varying not more than .003 in.

3. **Plugs.** Plugs must be merchant bar steel, 10 in. long, 31/32 in. in diameter, drilled for four ¼-in. rivets with drill 0.256; spacing to be 1 in., 2 in., 4 in., 2 in., 1 in., the outside holes to be in one plane and the inside holes to be in a plane at right angles to the outside holes.

4. **Rivets.** Rivets must be galvanized, must be of soft iron or steel ¼ in. in diameter, 1⅛ in. long.

SPECIFICATIONS FOR ONE-INCH WROUGHT IRON SIGNAL PIPE

1. **Pipe.** (a) Pipe must be genuine wrought iron made from puddled pig iron; no scrap will be permitted except the crop ends of wrought pipe. Pipe must be straight, tough, fibrous and uniform in quality throughout, free from cinder pockets, blisters, burns and other injurious flaws. Pipe must be hot galvanized inside and outside, unwiped.

(b) Pipe shall have a tensile strength of not less than 40,000 lb. nor more than 48,000 lb. per sq. in., an elastic limit of not less than 22,000 lb. nor more than 30,000 lb. per sq. in., and an elongation of not less than 12 per cent in a measured length of 8 in. Pipe must stand 1,000 lb. per sq. in. hydraulic pressure.

(c) When so required by the purchaser, the following test shall be made: (1) From each 1000 ft. of finished pipe, a piece 6 ft. long shall be cut from a length selected at random, and subjected to test as follows: (2) One man cut by hand, with standard stock and die, 1½ in. of thread; (3) punch two ¼-in. holes on welded seam, 2 in. and 4 in. from threaded end, without use of plug or filler piece; (4) Twist piece through angle of 180 deg. by clamping one end and turning the other end. After tests, if 20 per cent of the pieces show split or fracture at weld, the lot will be rejected.

(NOTE: Paragraphs 1b, 1c, 1f, 1g, 1h, 1i, 1j, 1k and Sections 2-Coupling, 3-Plugs, 4-Rivets in this specification are the same as those appearing in the preceding specification.)

See Compensation.

POLARIZATION. The collection of hydrogen gas, liberated by the electro-chemical action in a cell, on the negative element in the cell (the positive pole in the exterior circuit).

It is necessary for a commercial cell to be so designed that this gas will not form on the surface of this element. Otherwise, as hydrogen is a non-conductor, the internal resistance of the cell will be increased greatly, thus materially diminishing the current and voltage output. Polarization may be prevented by mechanical or chemical means and this is called depolarization. Chemical means are employed to depolarize signal service cells. When the hydrogen is caused to form a chemical combination,

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as it will with oxygen, if present, the internal resistance is not increased and the actual electromotive force of the cell may be slightly increased. The depolarizer used must be rich in oxygen, for which hydrogen has a decided affinity, and may be a liquid around the element as the copper sulphate solution in a gravity cell, or it may be a solid as oxide of manganese in a dry cell, or the depolarizer may be a part of the negative element (the positive pole in the exterior circuit) as the oxide in the copper oxide element of the Lalande cell which performs this function. This chemical action forms water which tends to dilute the electrolyte, consideration of which is recognized in the design of the cell. No depolarizer will keep the elecromotive force constant for all current outputs, for there is a certain limiting current which will form free hydrogen more rapidly than it can be absorbed by the depolarizing agent and this hydrogen will then collect on the element. See Cell.

R

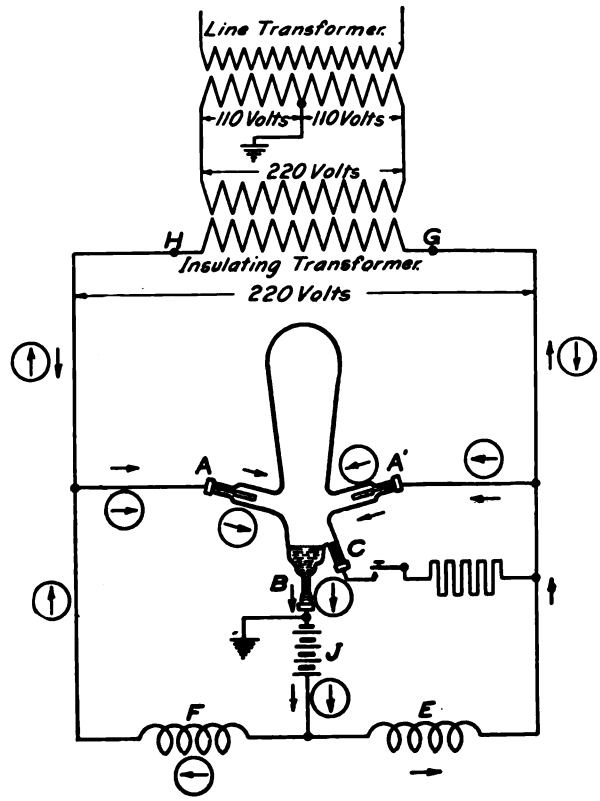
RAIL BOND. A wire or wires, used to connect the adjacent ends of contiguous rails in a track to insure continuity of the rail as an electrical conductor. See Bond Wire.

REAR. As relating to signals, a signal which is back of another. A distant signal is in the rear of (not in advance of) a home signal. With reference to the relative position of a signal and a train, a signal back of which the train has passed.

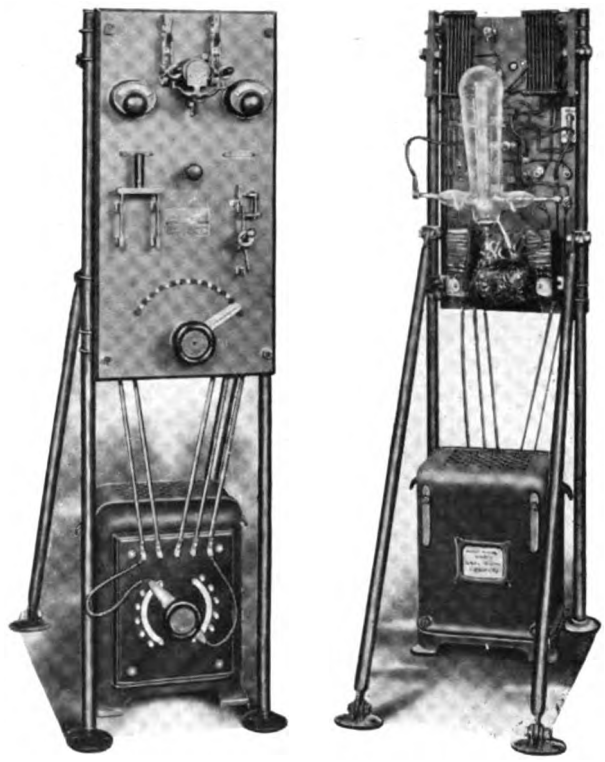
RECTIFIER. A device for converting alternating current into direct current.

This transition may be accomplished by means of a mercury arc rectifier, a mechanical rectifier, a chemical rectifier or other means.

All types of mercury arc rectifiers have three essential parts, the rectifier tube, the main reactance and the panel. The rectifier tube is an exhausted glass vessel in which are two graphite electrode (anodes A-A′) and one mercury cathode (B). Each anode is connected to a separate side of the alternating current supply, and also through one-half of the main reactance to the negative side of the load. The cathode is connected to the positive side. There is also a small starting electrode (C) connected to one side of the alternating current circuit through resistance, and used for starting the arc. When the rectifier tube is rocked to form and break a mercury bridge between the cathode (B) and the starting anode (C) a slight arc is formed and this starts what is known as the "excitation" of the tube, which condition can be kept up only as long as there is current flowing toward the cathode. Such a tube would cease to operate on alternating current voltage after one-half the cycle if some means were not provided to maintain the flow of current continuously toward the cathode. The maintenance of this current flow is accomplished by the main reactance. As the current alternates first one anode and then the other becomes positive. As the current flows through the main reactance it charges it and while the value of the alternating current wave is decreasing, reversing and increasing, the reactance discharges, thus maintaining the arc until the voltage reaches the value required to maintain the current against the counter electromotive force of the load



Control and Operating Circuits for Mercury Arc Rectifier



Mercury Arc Rectifier Panel, Front and Rear View
General Electric Company
(See Page 695)

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and reducing the fluctuations in the direct current. In this way, a true continuous current is produced with very little loss in transformation. The rectifier is so designed that the entire alternating current wave is used. The rectifier tube differs in size according to the ampere capacity, and in shape according to the direct current voltage at which it is to be used.

The principle of its operation is based on the fact that mercury vapor in its ordinary or molecular condition is practically a non-conductor of electricity. Such vapor might be formed by applying heat to a mass of mercury which is enclosed in a vacuous chamber.

If a body of vapor thus formed should be submitted to the action of an electromotive force, either continuous or alternating its resistance would be found to be very great. If, however, the vapor is ionized or, in other words, the atoms of mercury in this vapor are electrified, the electrical resistance to the flow of the current in one direction will be very small, while its resistance to current flowing in the opposite direction will still be great. It is easy to ionize mercury vapor as, if an arc is formed between one mercury electrode and another electrode, the mercury being the negative, ionized mercury vapor will result.

The mechanical type of rectifier, as it is being developed for use in signal work, generally consists of the transformer, resistance units, condenser, the vibrating element, etc. One side of the transformer is connected to the line while the secondary is connected to the rectifier movement and reduces the voltage to about 10 to 14 volts a.c., suitable for charging the ordinary signal battery for low voltage signal operation. The vibrating element is caused to operate by means of an electro - magnet, and it is essential that its vibration be synchronous with the number of cycles of a. c. In a 60 cycle a. c. system there are 120 alternations per second and it is necessary that the vibrator make 60 contacts per second in closing the battery charging circuit if but half of the a. c. cycle is used or it may be so arranged that the complete cycle is utilized by the use of two contact points or by other means. The use of the resistances or resistance and condenser is to obtain proper regulation of the current.

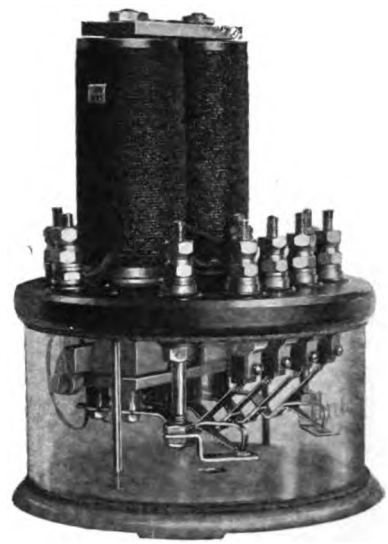
Rectifier Assembled for Service
Valley Electric Co.

The electrolytic rectifier differs from the other types in that there are no moving parts, the alternating current being rectified to direct current by means of chemical action. The containers for the electrolyte consist of glass or other suitable material, the electrodes being of metal rods, those used in one type being composed of aluminum and lead immersed in an electrolyte consisting of a compound of ammonia and potassium phosphate dissolved in distilled water. As in the other types of rectifiers, a small transformer and a resistance is necessary for reducing the line voltage and controlling the charging rate. The action which takes place when current flows is such as to prevent the current from flowing in but one direction. This type rectifies both halves of the wave and will operate under a wide frequency range. It is necessary to renew the active elements of this type of rectifier at certain intervals, depending upon the load it is required to rectify.

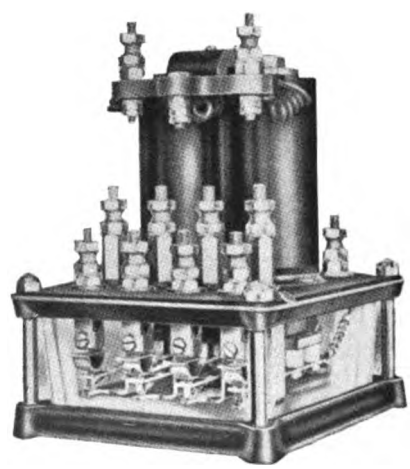
The mercury arc rectifier is used at power interlocking plants and similar locations for the charging of storage batteries while the mechanical and electrolytic types are beginning to come into use for the charging of a few cells of storage battery at signal locations, interlocking plants, highway crossings, etc. See A. C. Floating Storage Battery System. Also Condenser. Also Resistance. (See Page 826).

RELAY. An instrument, generally an electro-magnet, designed to repeat the effects of an electric current in a second circuit.

Relays may be divided between direct current and alternating current relays, the direct current relay



Shelf Type D. C. Neutral Relay
The Union Switch and Signal Co.



Shelf Type D. C. Neutral Relay
The Hall Switch and Signal Co.

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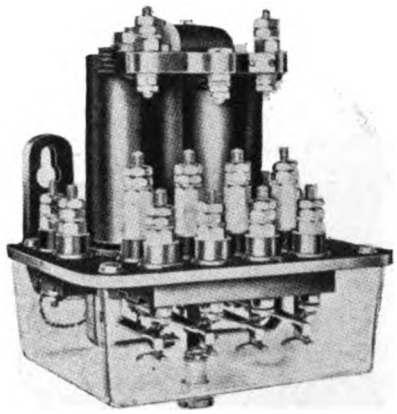
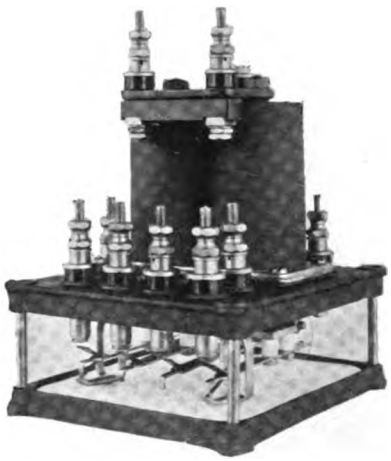
being designed to respond to direct current while the alternating current relay responds to a source of alternating current. In general a relay is designed to operate on a comparatively weak current, its purpose being to operate contacts which in turn close local circuits. For example, in a track circuit, the relay, adjusted to close its armature on the passage of the weak current of the track circuit, closes the strong local circuit which works or controls the signal system. A relay having a number of contacts can be made to close as many different local circuits. When the armature of a relay is attracted it closes a front contact and when the coils are de-energized and the armature falls away by gravity or is drawn away by a spring it closes the back contact, thus closing circuits which are to be made when the relay is in a de-energized condition. See Armature.

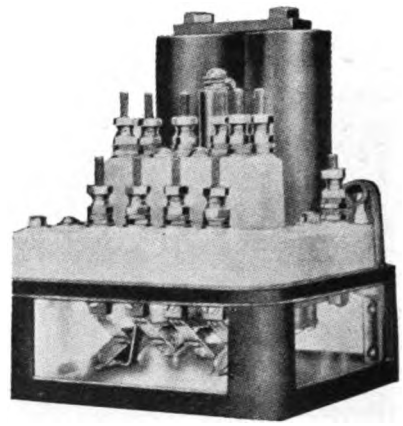


Wall Type D. C. Neutral Relay
The Hall Switch and Signal Co.

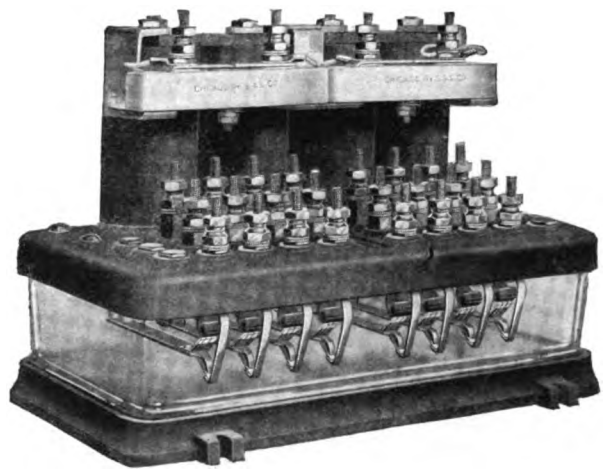


Shelf Type D. C. Neutral Relay
The General Railway Signal Co.

Wall Type D. C. Neutral Relay
The General Railway Signal Co.



Shelf Type D. C. Neutral Relay
The Chicago Railway Signal and Supply Co.



Shelf Type D. C. Neutral Double Relay
The Chicago Railway Signal and Supply Co.

RELAY, ALTERNATING CURRENT. A relay designed to respond to alternating current. Its function is to control the operation of an a. c. signal system, or of a d. c. system having a. c. track circuits.

The operation of the relay is based upon certain electrical laws and various designs are used to meet the different conditions encountered, particularly in track circuit work, where a type of relay should be used that will give the most economical operation under the given conditions. Some of the conditions influencing the type of relay used are d. c. or a. c. propulsion, in which use is made of one rail or of both for the return propulsion current; the length and type of the track circuits; the type of rail bonding; the kind of ballast and whether drained and

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ment type is used on short track circuits and around interlocking plants, while the double element type, consisting of a track element and a line element is

Alternating Current Vane Type Relay
The Union Switch and Signal Co.

employed on longer track circuits. See Relay, Induction Motor (Polyphase). Also Relay, Alternating Current.

RELEASE, SCREW. A manually operated device for releasing an electric lock, which through error or because of being out of order or by reason of some other abnormal condition, such as an error on the part of a leverman, holds a lever locked when it should be moved to avoid delaying a train at an interlocking plant.

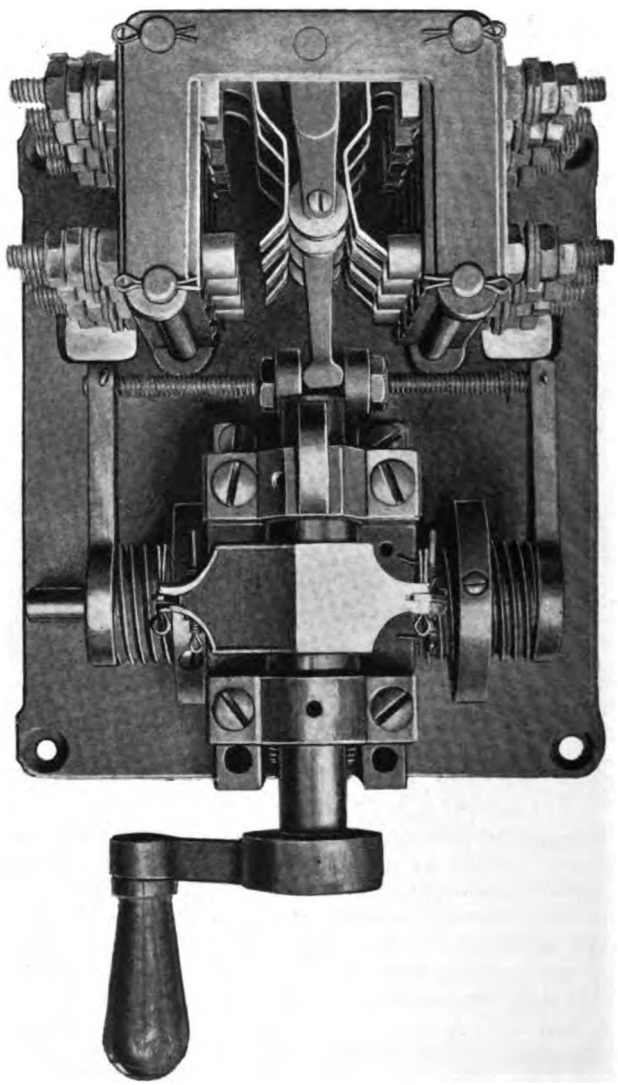
The release is so made that it can be operated only by turning a screw a certain predetermined number of times before it becomes effective thus preventing hasty action on the part of a leverman who, having a route lined up for an approaching train, may attempt to take it away hurriedly. The release must always be restored to its original position before normal operation of the interlocking machine can take place.

The time required to operate the release may vary from 10 seconds to 5 minutes or more, depending upon the traffic, braking distance and other conditions existing at the plant. The time required to operate the device should be such that it will not be possible for the leverman to place the signals governing the route in their normal position, operate the release and then open the derail in the face of a train which had accepted the route; the time required should also be long enough that a train may have been brought to a stop before the leverman can change his route. See Locking, Electric. Also Release, Time.

RELEASE, TIME. A device for releasing an electric lock on a signal or other lever to avoid train detention. An electric lock may remain locked because of the leverman setting up a route or because the route set up was not desired or because of abnormal conditions.

A time release may be operated entirely manually or automatically, after having been once started by the leverman. An automatic release is employed where the leverman's other duties may sometimes conflict with manual operation as at busy interlocking plants. The time interval of such releases may be varied from a few seconds up to ten or more minutes. Time releases may be of the screw, clock work, mercury, thermostatic, electric or mechanical types. The mechanical release, in its operation, raises a lock armature by a lifting dog operated by the release, at the same time locking certain levers in the interlocking machine by means of locking dogs attached to a locking bar which is moved by the release, thus insuring that the release is placed at normal before other routes can be set up.

The electro-mechanical release performs functions similar to the mechanical release, but in addition it makes and breaks contacts controlling electric circuits, while in the operation of the electric screw



Hand Operated Time Release
The Federal Signal Co.

release, contacts controlling electric circuits are opened and closed. Hand-operated snap or knife switches are sometimes used in place of a screw release in which case they are generally placed in the first story of the tower or in some remote location so that it will take the leverman some time to reach them, thus providing the time interval obtained with

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a screw release. See Locking, Electric. Also Time Release, Clockwork. Also Release, Screw.

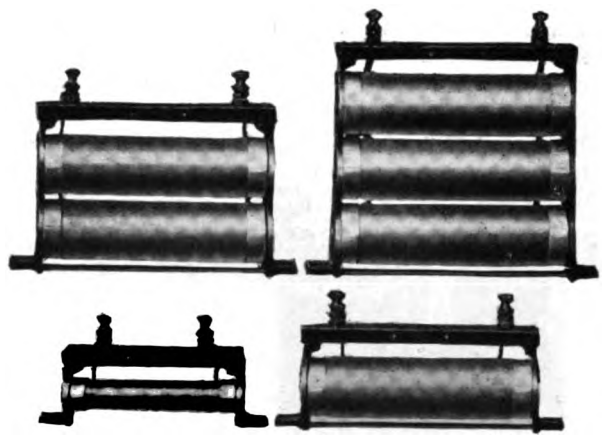
RELUCTANCE. The magnetic resistance offered by a magnetic circuit to the passage of the lines of force.

No recognized name exists for a unit of reluctance although the centimeter-gram-second unit is sometimes called the Oersted. The magnetic resistance offered by a magnetic circuit to the passage of lines of force is the principle employed in the design of slow acting armatures, etc. Reluctance does not possess a constant value when applied to iron or steel forming a magnetic circuit and in this respect is unlike the resistance of an electric circuit which can be calculated for a given size wire and remains constant for it under the same conditions regardless of the amount of current the circuit may be carrying. Reluctance as applied to wood, glass, metal, stone and other materials except iron and steel is practically the same as air or as if these substances were not present. Reluctance of iron and steel is an exceedingly variable quantity and depends upon the density of the flux or lines of force. Doubling the electromotive force in an electric circuit having a fixed resistance will double the current flowing but doubling the magneto-motive force applied to a magnetic circuit composed of iron or steel will not double the flux through this reluctance. In general, the reluctance of a piece of iron or steel increases as the flux sent through it increases but this increase in reluctance is not in direct proportion to the increase in flux. See Ampere Turn.

RESISTANCE. That property in a circuit which opposes or retards the flow of an electric current. In direct current the resistance, according to Ohm's Law, is the ratio between the electromotive force which causes the current to flow and the current so produced and $R=\frac{E}{I}$. In an alternating current circuit resistance is the component of impedance or total retarding effect which is in phase with or parallel to the current. The unit of measurement of resistance is the ohm. See Ohm.

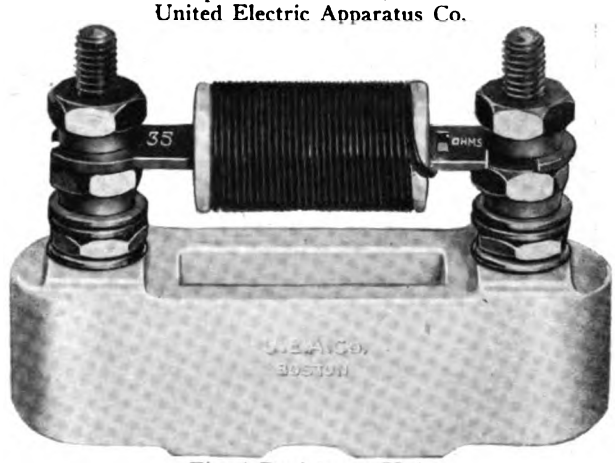
RESISTANCE UNIT. A device having the property of opposing or retarding the flow of an electric current.

In general, a resistance unit consists of wire of the proper size and kind, wound in the form of a coil or tube and mounted on a suitable support or base for

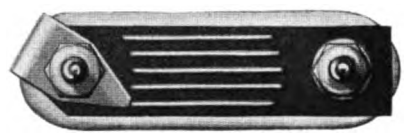


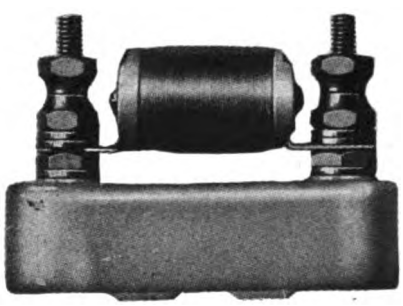
Resistance Units
The General Electric Co.
(See Page 695)

Inspectors Resistance Box
United Electric Apparatus Co.

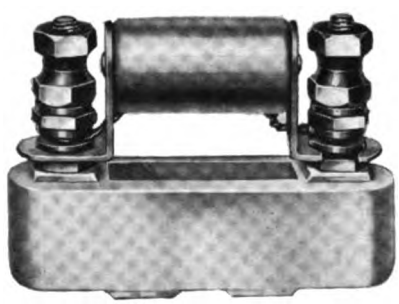


Fixed Resistance Unit
The United Electric Apparatus Co.
(See Page 823)

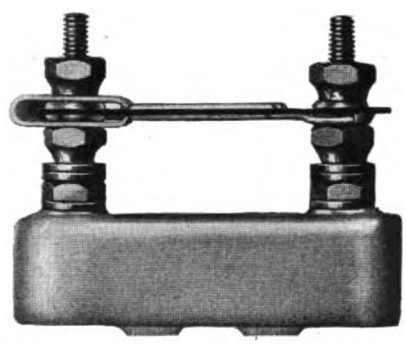




Resistance Unit on R. S. A. Terminal
The General Electric Co.
(See Page 695)



Resistance Unit on Terminal Block
The Union Switch and Signal Co.



Variable Resistance Mounted on
R. S. A. Terminal Block
The Union Switch and Signal Co.

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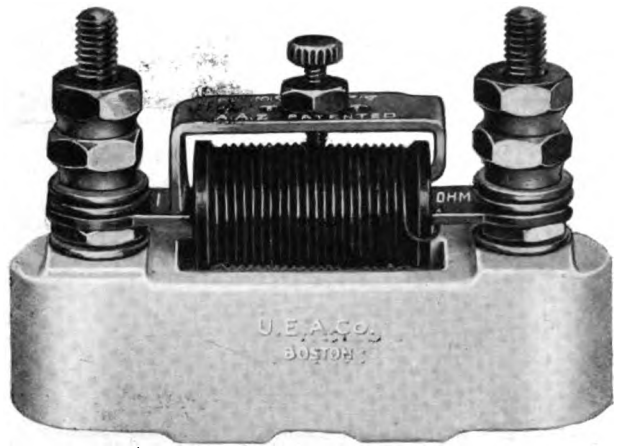
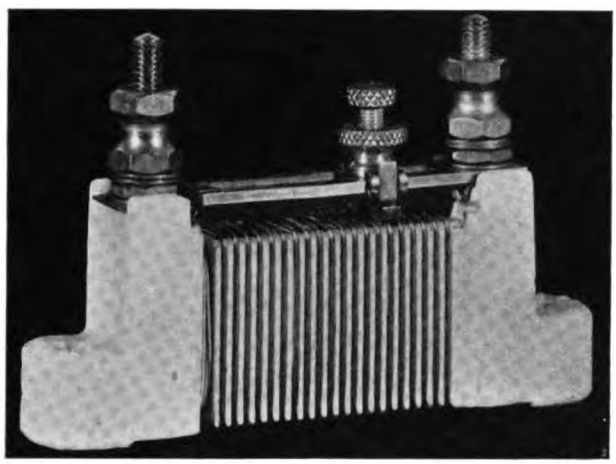
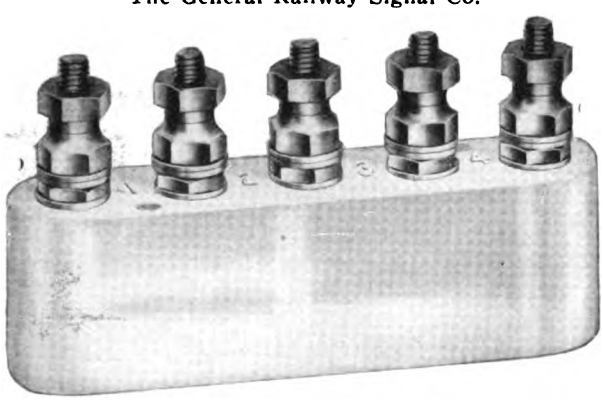
connecting into an electric circuit in which it is desired to reduce the flow of electricity. Resistance units are employed extensively in signal work. They are used in connection with all track circuits on which Lalande (caustic soda) cells or storage cells



Adjustable Resistance Unit
The United Electric Apparatus Co.
(See Page 823)



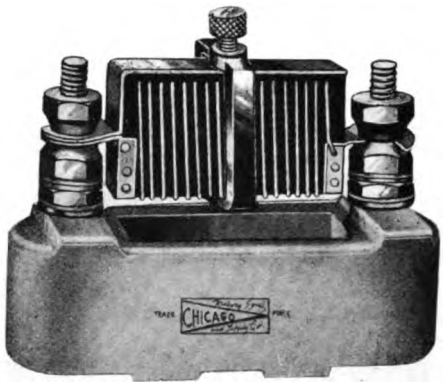
Adjustable Resistance Unit
The General Railway Signal Co.



Adjustable Battery Resistance Unit
The L. S. Brach Manufacturing Co.

are used. This is necessary because of the comparatively low internal resistance of the cells by reason of which an excessive amount of current would flow from them when a train was on the circuit, thus providing a path of negligible resistance from the battery to the rail, through the wheels and axles to the other rail and back to the battery. In addition to preventing an excessive current flow and thereby prolonging the life of the battery, the resistance unit (which is of the adjustable type) also provides for safer relay operation which is of great importance.

Among other uses around power interlocking plants, resistance units are used on the operating switchboards, so designed with the proper resistance

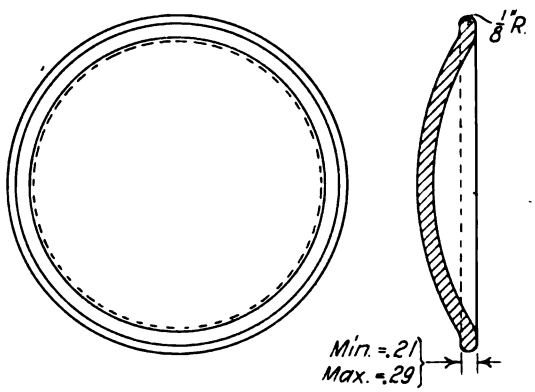


Adjustable Resistance Unit
The Chicago Railway Signal and Supply Co.

that if the automatic circuit breaker on the board should open for some reason when a signal or signals were cleared for an approaching train enough current is allowed to flow around the circuit breaker and through the resistance unit to hold the signals in the clear position, but not enough current is allowed to flow to operate them to the clear position once they are at stop.

Resistance units find extensive use in connection with other signal circuit work. The unit may be made up of a special wire having a high resistance and which is non-oxidizing on heating, or of copper or other wires, insulated or non-insulated, depending upon the manner of mounting and the use to which it is to be put. It may be made up in the form of a porcelain, or of a vitreous enameled tube and with leads from which various resistance values may be obtained; or the wire may be non-insulated and wound on a non-inductive core as of fiber or porcelain and so arranged that a graduated resistance can be obtained by a movable contact. See Resistance. Also Track Circuit. Also Cell, Lalande. Also Cell, Storage.

ROUNDEL. A round, flat or convex piece of white or colored glass used in signal lamps to produce the night signal indication.



Signal Roundel

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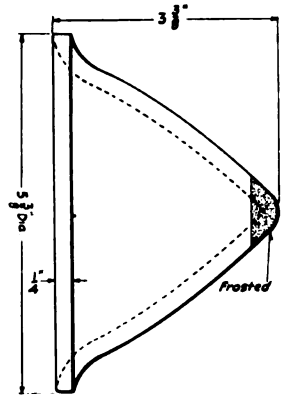
In general, colored roundels are used in semaphore castings which pass in front of the semaphore lamps which are themselves usually fitted with white lens; lunar white roundels are used often in connection with marker lights in automatic signal and interlock-



Cover Glass for Light Signals

ing territory. Red, yellow, green, lunar white, purple and blue roundels are specified by the R. S. A., the two diameters most generally used being 5⅜ in. and 8⅜ in. The specification for signal roundels, lenses and glass slides as adopted by the R. S. A. in 1918 follow:

Specification for Signal Roundels, Lenses and Glass Slides

1. General.

(a) Material. 1. Glass shall be of a composition which is durable on prolonged exposure to the atmosphere. Colored glass shall be of a uniform, solid color. Flashed glass will not be accepted.

2. Glass shall have a refraction index of not less than 1.50 and a specific gravity of not less than 2.50.

(b) Workmanship. Workmanship shall be of the best; glasses shall be true to size and form, and practically free from chips, bubbles, streaks and wrinkles and shall have the name or trade mark of manufacturer pressed on the outer zone.

(c) Color: Red, green, yellow, blue, purple and lunar white glasses will be purchased.

(d) Wrapping. Each glass shall be wrapped in paper of corresponding color.

(e) Tests. 1. Manufacturer shall give the purchaser sufficient notice of time when material will be ready for testing.

2. Manufacturer shall provide, at point of production, apparatus and labor for making required tests under the supervision of the purchaser.

3. Manufacturer shall test each glass, placing thereon a label showing that the photometric value falls within the dark and light limits shown in section 2-b, and shall submit all red glass to the sodium test.

4. Purchaser reserves the right to make repetition of the above tests.

(f) Samples: Manufacturer shall submit samples of glasses, showing the extreme limits of colors which it is proposed to furnish. These shall bear labels showing the photometric values, and if approved, will be kept in the office of the signal engineer, as standard.

(g) Inspection. 1. Purchaser will make such inspection of the completed product as to assure him that the requirements of the specification have been met.

2. Purchaser may make desired inspection at all stages of manufacture.

3. If, upon arrival at destination, the material does not meet the requirements of this specification, it may be rejected and returned to the manufacturer, who shall pay all freight charges.

4. If purchaser is to make inspection at point of production, it shall be so stated.

(h) Re-hearing. When tests are made at the purchaser's laboratory, samples of the rejected material will be held for one month from date of test report. In case the manufacturer is dissatisfied with the result of tests, he may make claim for re-hearing within that time. Failure to raise a question within one month will be construed as evidence of satisfaction with the result of tests. The samples will be scrapped and claim for re-hearing will not be considered.

2. Roundels.

(a) Design. 1. Roundels shall either be of the convex or flat type, as specified, and of high transmission glass, and be between 0.21 in. and 0.29 in. in thickness.

2. New designs shall be confined to 8⅜ in. in diameter for high signals and 5⅜ in. in diameter for low signals.

(b) Photometric values. 1. Roundels will be subjected to spectro-photometric analysis. The following table gives an analysis of roundels of the various colors of medium intensity, the first row of figures, marked "Wave Length," being the wave length of the light in different parts of the spectrum measured in thousandths of a millimeter, and the other rows of figures are the percentages of light of the wave length given in the first row, which the different roundels transmit. Roundels of medium intensity should transmit light as nearly as possible of this composition:

Wave Length	Red	Yellow	Green	Blue	Purple	Lunar White
.41	0	0	40	80	90	90
.43	0	0	53	73	82	80
.45	0	0	62	68	74	69
.47	0	0	68	54	59	65
.49	0	0	70	27	18	54
.51	0	2	64	10	5	38
.53	0	8	48	2	1	22
.55	0	18	30	2	.5	23
.57	0	29	16	1	.5	26
.59	0	42	6	0	0	11
.61	0	50	3	0	0	12
.63	47	54	1	0	0	11.5
.65	74	57	0	0	0	10.5
.67	78	57	0	0	.2	23
.69	75	55	0	1	12	51
.71	74	52	0	2	52	79

2. Comparison of old and new R. S. A. photometric scales. The R. S. A. in 1918 adopted certain medium photometric standards for the respective signal colors, designating such medium values as 100 (i.e., 100 per cent). The present high transmission colors corresponding to the table of wave lengths above permit an increase of the medium photometric values as shown in the following table. Manufacturing conditions require a reasonable variation from the medium as shown by the light and dark limits, respectively.

	Light Limit	Medium Intensity	Dark Limit	Extreme Variation from Medium
Red	160	130	100	23%
Green	175	150	125	16⅔%
Yellow	140	120	100	16⅔%
Blue	125	100	75	25%
Purple	125	100	75	25%
Lunar white	120	100	80	20%

3. Red.—Shall be of such quality that all yellow rays of light emitted by the sodium flame are absorbed, the spectrum being either red, or red and orange.

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4. Green—Shall be of the color known as admiralty green, having a slightly bluish tint as seen in daylight. The spectrum shall show most of the blue and green, a slight amount of yellow and not more than a trace of orange and red.

5. Yellow.—Shall give a spectrum showing most of the red, all of the yellow, and part of the green, but no blue.

6. Blue.—Shall give a spectrum showing most of the blue, some green, and almost no red.

7. Purple.—Shall give a spectrum showing most of the blue, some green, and a narrow band of the extreme red.

8. Lunar white.—Shall show blue and green, with about ten per cent of yellow and orange, and some red. It shall appear a light blue when viewed by daylight, and when placed in front of a yellow kerosene flame, it shall make this flame appear white.

3. **Lenses.**

(a) Design. 1. Lenses shall be of the polyzonal design and one of the following types or the equivalent according to requirements:

(a) Optical. Optical lenses shall have a smooth outer face.

(b) Inverted. Inverted lenses shall have a smooth inner face.

(c) Optical and inverted. Optical and inverted lenses must focus to an area not exceeding ⅜ in. in diameter, for all lenses up to the 6-in. size, nor exceeding ½ in. in diameter for the larger sizes. When observed along the axis from a distance of 20 to 40 ft., a small oil flame being placed in the focus, the whole lens shall appear equally illuminated, the risers of the steps showing only as narrow, dark rings.

(d) Spreadlite. Spreadlite lenses may be either of the optical or inverted type, with cylindrical segments on the smooth face.

(e) Yard (wide angle).

(f) Fresnel.

(g) Multi-fresnel.

2. Lenses 6⅜ in. and over in diameter, except the yard (wide angle) type, shall have at least 5 zones, and smaller lenses 4 zones.

3. New designs shall be confined to lenses of the diameter shown in sections 3-a and 3-c.

(b) Color. Colored lenses shall have the same photometric and spectro-photometric value as roundels of the same color.

(c) Focal length. The focal length of each lens shall be pressed on the outer zone, and shall be in accordance with following table:

Diameter.	Focal Length.	
4 in.	2¾ in.	
4½ "	3½ "	When used in lamp with 5-in. lens.
5 "	3½ "	
5⅜ "	3½ "	
6⅜ "	3¾ "	
8⅜ "	1½ or 5 "	
10 "	6 "	

4. **Glass slides.**

(a) Material. Thickness of slide shall be not less than 0.095 in., and not more than 0.15 in.

(b) Design:

Slides shall be { cut / pressed } to size ordered.

(c) Color. Slides shall have the same photometric value as roundels of the same color.

5. **Illumination.** The R. S. A. standard color light signal is based on the use of the ordinary yellow kerosene flame as a source of illumination.

6. **Marking.** (a) Purchaser's order and requisition number, name of consignor and name and address of consignee, shall be plainly marked on outside of package.

(b) Detail list of loose pieces, containers and their contents shall be furnished for each shipment. Where carload shipments are made, show routing and car identification.

7. **Packing.** Material shall be packed so as to permit convenient handling and to prevent loss or damage during shipment. (See Page 673).

ROUTE. A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, as in a yard; or any one of several possible combinations of turnouts or crossovers by which a train may travel from one place to another, such as at interlocking plants.

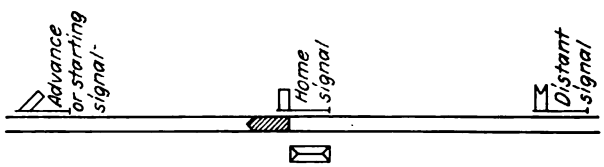
S

SEMAPHORE CASTING. A casting consisting of cast iron, or cast iron and sheet steel, comprising the arm casting and spectacle of a semaphore signal. See Arm Casting (Semaphore).

SIGNAL. A sign agreed upon to convey information, especially at a distance.

Specifically, in train operation, a means of conveying information to the person or persons in immediate charge of the movement of a train. Its use is confined in this book to fixed signals, as distinguished from hand motion signals, etc.

SIGNAL, ADVANCE. A signal placed some distance in advance of a home signal at a block or interlocking station and having the same function as the home signal. It provides in effect a short block section in which a leverman may hold a train while not interfering with the movements of trains in the main block section, either in advance or in the rear.



Illustrating an Advance Signal, together with Home and Distant Signals, at a Manual Block Station

Such a signal is used frequently at an interlocking plant where a joint passenger station is located and where traffic is such that a train on one railway line may be working at the station while trains on the other railway line wish to use the crossing. An advance signal located near the crossing in connection with an additional derail will allow such moves to be made.

SIGNAL, ADVANCE BLOCK. A fixed signal used in connection with a home block signal to subdivide the block in advance. This, in effect, provides a short block section, as it is employed to govern train movements between it and the home signal on main tracks and from sidings to main tracks. (Used principally in manual block signaling.) By its use a train may clear the block section to the rear, preventing delays to a following train which may then pull up to the home signal. Its location is

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governed by the operating conditions existing at that point. It should be located so that no inconsistency is introduced in train operation and so that an absolute stop indication of the signal shall not be violated by trains making switching movements.

SIGNAL, BANJO. A common name for the enclosed disc signal. See Signal, Enclosed Disc.

SIGNAL, BANNER. A common name for the clock work signal. See Signal, Clockwork.

SIGNAL, BLOCK. A fixed signal governing the use of a block. (A. R. A.)

This signal may be a mechanically or power-operated semaphore signal working in two or three positions, upper or lower quadrant; a disc signal; a color light or position light signal. Certain interlocking signals may also serve as block signals. See Signal, Fixed. Also Signal, Home.

SIGNAL BOX. A British term for a signal cabin or interlocking tower. See Tower, Signal.

SIGNAL, CAUTION. A signal indication regulating the approach of a train to the next signal.

In permissive block signaling (manual block) a caution signal is accepted for a train movement with the understanding that a train moving in the same direction is ahead and may be overtaken at any point in the block section; the engineman must accordingly handle his train at a low speed unless the track is straight for a considerable distance ahead and the view is unobstructed. At interlocking plants a distant signal is used to regulate the approach to the home signal and gives a "caution" or clear indication, depending on the approach desired. The distant signal is located from 1,200 ft. to a mile or more from the home signal. In three-position signaling the blade of the distant signal, at an angle of 45 deg. gives a caution indication, and at 90 deg. gives a clear indication. If this signal is located in automatic signal territory it then also takes a horizontal position and then becomes both an interlocking distant signal and an automatic block signal. The A. R. A. block signal rules designated this as an approach signal, the indication being "approach next signal prepared to stop." This means that the block is clear but that the second block in advance is not clear.

SIGNAL, CLEAR. The term used to denote the indication of a signal in the "proceed" position.

In two-position lower-quadrant signaling the arm inclined downward at an angle of 60 deg. gives this indication. In three-position lower or upper quadrant signaling the arm in the 90-deg. position is spoken of as a "clear signal." At interlocking plants the term may refer to a home signal indicating "proceed at unlimited speed"; or to such a signal indicating proceed at limited speed over a diverging route while a distant signal indicating "proceed, expect to find the next signal clear" is designated by the same term. In manual block territory the term is applied to the signal indication giving a train the right to enter a block which is clear.

SIGNAL, CLOCKWORK. A signal mechanically operated but electrically controlled, which gives its indication by means of a disc or a target revolving on a vertical spindle.

The spindle operating the disc is rotated through a chain of gears similar to the works of a clock by a weight suspended inside of the iron signal post. A detent operated by an electro-magnet controlled by the track circuit prevents the disc from revolving more than one quarter of a revolution for each operation of the signal. The day indication is given by the disc or target which, when visible to an engineman, indicates stop and when turned with the edge towards the approaching train (disc not visible) indicates clear.

A common form of clockwork signal has a second target of a different shape mounted on the spindle at right angles to the stop target which serves for the clear indication. The stop target is usually painted red and the proceed target, when used, is painted white or green, the night indications being given by colored lights. This is one of the early forms of automatic block signal mechanisms and is still in use to a limited extent in New England but is now practically an obsolete type. See Signal Colors, Night.

SIGNAL, DISC. A signal in which the day indications are given by the color or the position of a circular disc. This term is commonly used for the enclosed disc signal.

A clock work signal is a disc signal in which the day indications are given by the position of the disc as it is turned to one or another of two positions by the revolution on its axis of a vertical spindle. But few clockwork signals are in service and they are now obsolete while the enclosed disc signal is fast becoming obsolete as a block signal. See Signal, Enclosed Disc. Also Signal, Clockwork. Also Highway Crossing Protection.

SIGNAL, DISTANT. A fixed signal used in connection with one or more home signals to govern the approach thereto (A. R. A.). This signal is located from 1,200 ft. to a mile or more in the rear of a home signal to regulate the approach to it.

In two position lower quadrant signaling a fish tail blade is usually the distinguishing mark to designate it from the signal governing the entrance to the block. In three position upper or lower quadrant signaling, each signal gives a distant indication for the signal in advance and when the blade is in the 45-deg. position it indicates that the signal ahead is in the stop position but that the intervening block is clear.

When a distant signal is in the "clear" position a train may proceed at unchecked speed, but when in the "caution" position a train must regulate its approach to the next signal. A distant signal is necessary in order to avoid delays to fast trains, where the view of the signal governing the entrance to the block is obstructed by physical conditions or where atmospheric conditions may obscure the vision of the engineman.

At interlocking plants a distant signal is so interlocked that it cannot be "cleared" until the home signal is cleared and if there are other signals for that route on that track, the distant signal is interlocked so that all of them must be cleared before it can be cleared.

When a distant signal is fixed on a post with the home signal for the next section in the rear, it is controlled by the latter so that when it indicates "stop" the distant signal will indicate "caution" even if its own home signal a block in advance does not require it to do so. This is done to avoid giving to an en-

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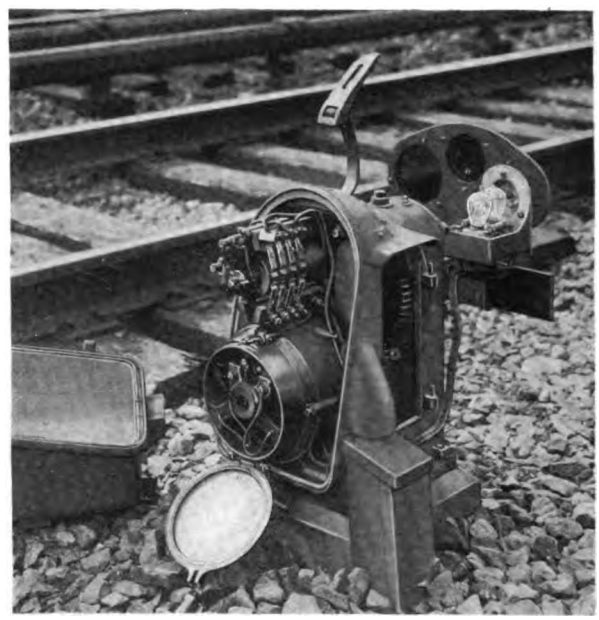
gineman what might seem to be two different signal indications inconsistent with each other at the same point. See Signal, Caution. Also Signal Colors, Night.

SIGNAL, DISTANT SWITCH. A signal, either mechanically or power operated, located from 1,000 ft. to 3,500 ft. or more form the facing outlying switch which it is to protect, and used to indicate the position of the switch.

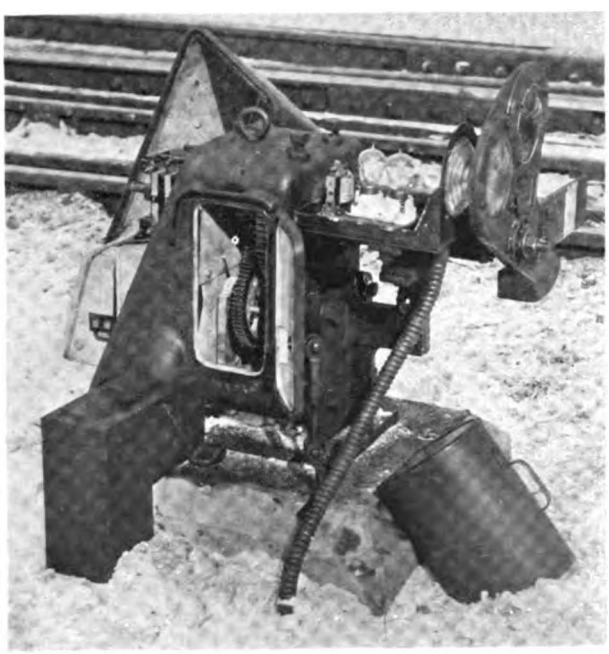
A mechanical signal is operated by a wire line and its operating lever is usually interlocked with the lever of the switch. These signals were used frequently before block signals were common but with the introduction of the block system and interlocking these signals are usually removed or made a part of the system. As a wire-connected signal is hard to keep in adjustment and cannot always be depended on to give an indication corresponding to the position of the switch, the present tendency is to use a power-operated signal controlled by the track circuit between the signal location and the switch it protects and by the position of the switch. This distant switch signal is used principally to protect outlying switches located on curves or in places where the view is obstructed and by the use of a track circuit offers additional protection. This type of signal, in connection with track circuits, is also used for station protection.

SIGNAL, DWARF. A low home signal. (A. R. A.). A low semaphore or other signal used to give indications for low speed movements, as through an interlocking plant in the reverse direction to the normal current of traffic or to or from a side track.

These signals are used frequently at terminals to give indications in the normal direction where the running speed is necessarily slow and also in some instances for train movements from the normal direction from a main track to a side track, the dwarf being set close to the high signal post. The dwarf signal arm is about three inches wide and nine inches long and usually approximately two feet above the level of the rail. The blade is often made of rubber or thin sheet metal to prevent damage in case cars or engines foul it. In some cases a white enamel-faced, round sheet metal disc with a red enameled blade across it is used in lieu of a blade. The day indications are the same as for the high semaphore signals and may be given in the lower or upper quadrant, two or three position. A three position dwarf generally is used, however, only in large terminals in connection with power interlocking and track circuits. Night indications are given by color.



Mechanism of Alternating Current Motor-Operated Dwarf Signal
The General Railway Signal Co.



Dwarf Signal Mechanism
The Federal Signal Co.

Three or Four Position Light Dwarf Signal
The Union Switch and Signal Co.

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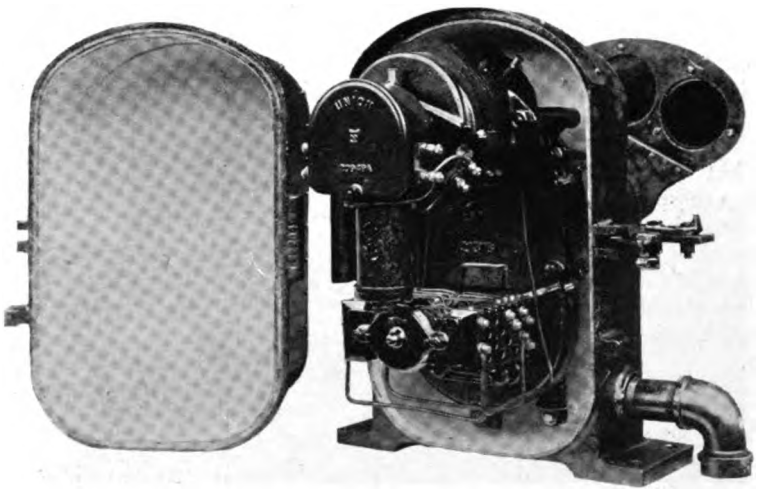

Motor-Operated Dwarf Signal Mechanism
The Union Switch and Signal Co.

Position light dwarf signals are also used in which a beam of light appearing in the horizontal, 45 deg. and vertical positions conveys the same indications as does a three position dwarf semaphore blade working in the upper quadrant. The latest development in the use of the position light dwarf signal is one giving four indications instead of three. These indications consist of the customary three upper quadrant ones and in addition, one in the 45 deg. position at 90 deg. around from the usual 45 deg. aspect.

This type of signal can be used to advantage in congested terminal territory to accelerate train movements and at the same time provide an indication for very slow, cautious moves when necessary. It will also be valuable in signaling or giving information to enginemen as to whether long platform tracks in terminal stations are occupied by trains or cars.

The lights in the horizontal position denotes stop; in the 45 deg. position, proceed at authorized speed prepared to stop at next signal; in the 90 deg. position, proceed at authorized speed. The fourth position gives a permissive signal for a train to occupy track, and it must proceed with caution prepared to stop short of other train or obstruction. See Signal Colors, Night.

SIGNAL, ELECTRO-GAS. A semaphore signal which is operated by compressed carbonic acid gas, the operation being controlled through the medium of an electro-magnetic valve which in turn is controlled by an external track or line circuit.

The signal arm is connected to a vertical rod which in turn is attached through suitable connections to a movable cylinder in which is a fixed piston. The flow of gas into the cylinder for the purpose of clearing the signal and the escape of the gas after it has cleared are controlled through valves, which in turn are controlled by electro-magnets, while a lever or clutch which holds the signal clear is controlled by a back armature on these magnets. The gas is stored in an iron cylinder at the foot of the signal post at a normal pressure of from 600 lb. to 1200 lb. per sq. in., which is reduced through a regulating valve to from 40 lb. to 60 lb. per sq. in. for use. This type of signal is employed to a limited extent in automatic signaling in various parts of the country, there being a total of 1602 miles of track protected by this type of signal in the United States as of January 1, 1920. It is also used to a certain extent for distant signals for interlocking plants but it is fast becoming obsolete.

SIGNAL, ELECTRO-PNEUMATIC. A semaphore signal operated by compressed air, the operation being controlled by means of electro-magnetic valves which in turn are controlled by external circuits.

In electro-pneumatic interlocking the electric control is under the jurisdiction of the leverman in the tower. While in electro-pneumatic block signaling the air valves at the signals are controlled by the track circuit. Each signal is operated through suitable connections by a single-acting cylinder, 3 in. in diameter with a 4¼ in. piston stroke for high signals and 2¼ in. for dwarf signals. The admission of air to the cylinders is controlled by a pin valve and electro-magnet. The signals have circuit controllers operated by the cylinders for opening or closing contacts controlling various circuits. A source of air supply at a pressure of approximately 75 lb. per sq. in. and of current at about twelve volts is required for the operation of the signal. Single acting cylinders are employed as the signal blade returns to its stop position by gravity. These signals may be operated in either two or three positions, upper or lower quadrant and giving right or left hand indications by lever (in interlockings) only, by track circuit or by a combination of both and may be used in connection with either a. c. or d. c. work. In three-position signals two cylinders are required, one for the 45 deg. position and one for the 90 deg. The air supply goes to the valve and cylinder for the 45 deg. position while that for the 90 deg. valve and cylinder is drawn from the 45 deg. position cylinder in order to insure that the clear position of the signal is dependent upon the caution position having first been obtained and to insure that, on interrupting the air pressure or the electric current by which the signal is held in the clear position, it will return from this position irrespective of which magnet or valve is deprived of power. This type of signal is used to a limited extent for automatic signaling, there being about 1850 miles of track so protected in the United States in 1920. However, it finds its greatest application in connection with electro-pneumatic interlocking plants.

SIGNAL, ENCLOSED DISC. An electrically operated signal, which gives its indication by means of a circular disc of light cloth or thin metal, enclosed in a weather-proof case with a glass front and mounted on a pole by the roadside or on a bridge or other structure above the tracks.

The circular disc is displayed for the day indication of stop or caution and is withdrawn from sight for the proceed indication. It is essentially a two-position signal. The disc is red for the home (stop) signal and yellow or green for the distant signal, according to the colors used for the night indication. Both the day and the night indications are given by color. The ease with which a disc signal may be

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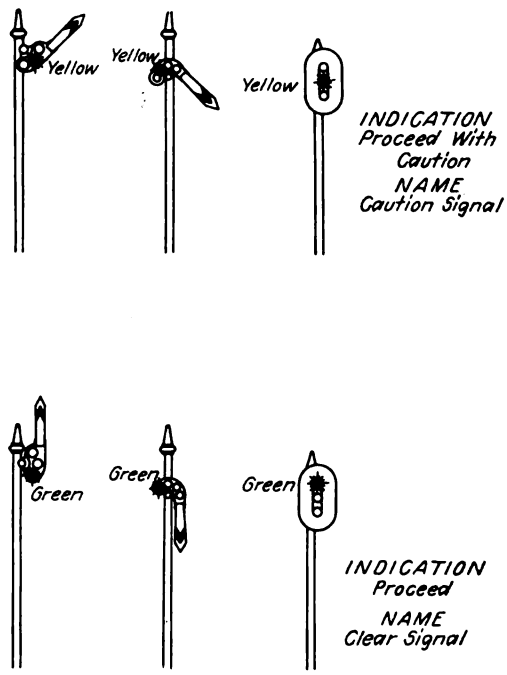
observed is dependent upon the contrast between the appearance of the disc and that of the surrounding surface of the case. When the signal is cleared by the disc being withdrawn from sight, the inner surface of the back of the case, which is white, constitutes the clear signal. This type of signal is rapidly becoming obsolete as an automatic signal, but is being used to a small extent as a highway crossing warning to give visual indication of the approach of a train. In such locations it is used either with or without the audible warning bell. This signal is the simplest and earliest form of automatic block signal, having been introduced in 1871. See Signal Colors, Night. Also Highway Crossing Protection.

SIGNAL, FIXED. A signal of fixed location indicating a condition affecting the movement of a train, as distinguished from signals given by motion of the hand or by a flag or a lamp. A term sometimes applied to a fixed or immovable arm used as a marker, as at some interlocking plants where such an arm may fit in with the plan of signaling employed although it may govern no route. In other cases a fixed marker and marker light are used instead of a fixed arm. Flags or hand lanterns may be set temporarily in fixed locations. All block and interlocking signals are fixed signals.

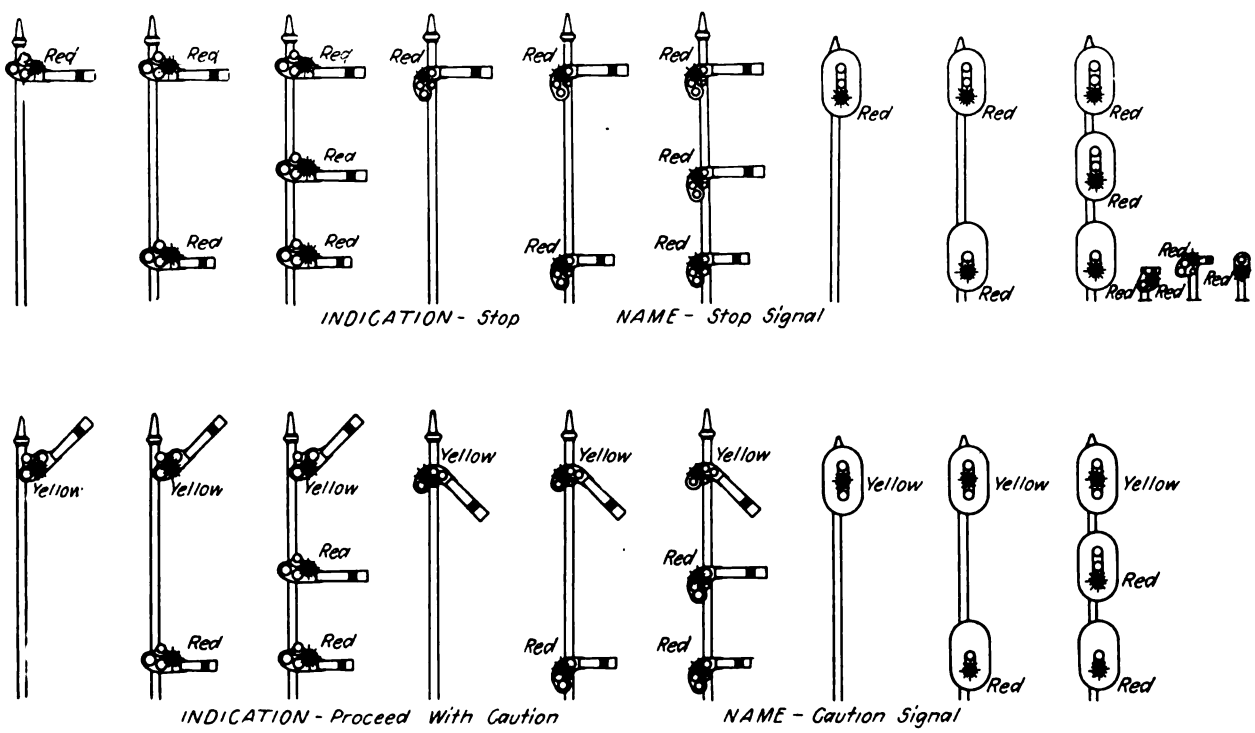
SIGNAL, HIGH. A full-sized semaphore signal, mechanically or power operated, or fixed, mounted on a post located on the ground, bridge, building or other structure so that it is above the level of the top of a car or locomotive.

When two or more high arms are mounted on the same signal mast the lowest one is usually placed at a minimum height of 20 ft. above the level of the rails and a minimum vertical distance of 6 ft. is maintained between arms on the same mast. All signals for trains running at full speed are high signals, low signals being used only for slow movements. See Signal, Dwarf. Also Signal, Pot. Also Signal, Semaphore. Also Signal Mast. Also Slow Speed (Calling On) Arm.

SIGNAL, HOME. A fixed signal at the entrance of a route or block to govern trains in entering and using said route or block (A. R. A.). As a block



Three-Position Distant Interlocking Signal Indications on the Chicago, Rock Island & Pacific



Three-Position Home Interlocking Signal Indications on the Chicago, Rock Island & Pacific

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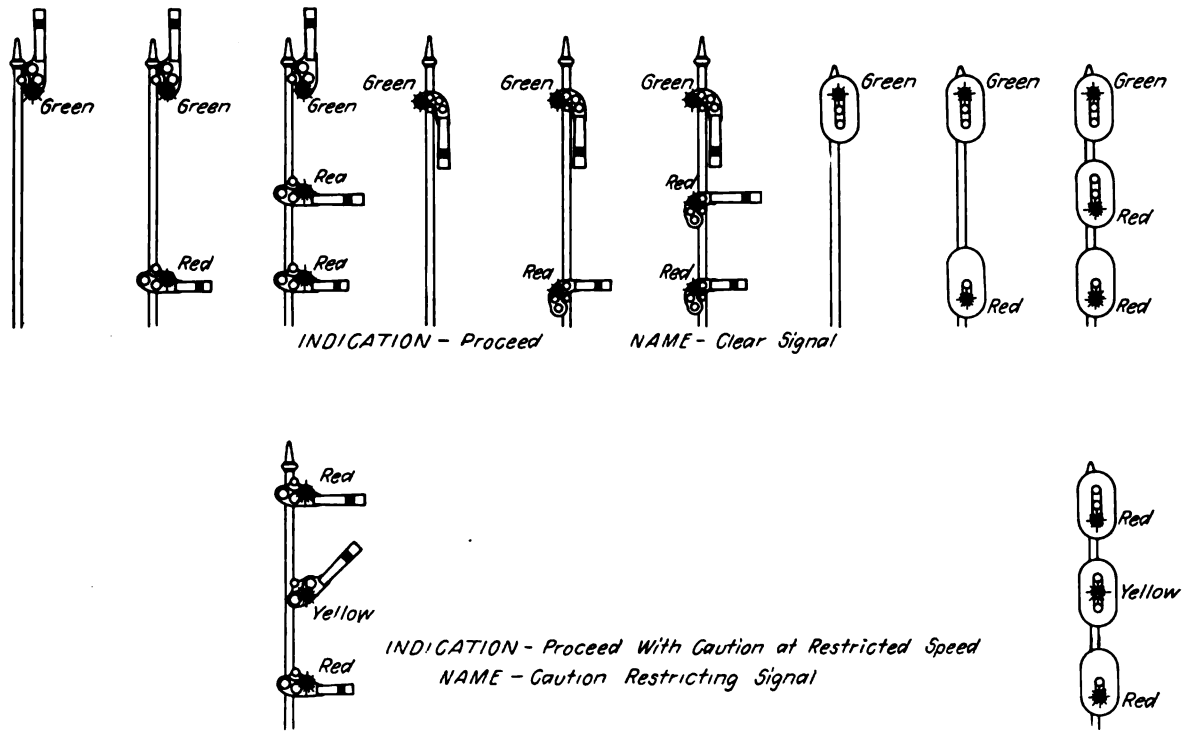
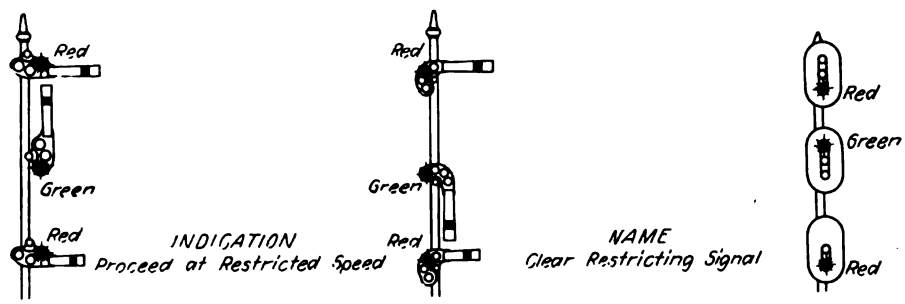
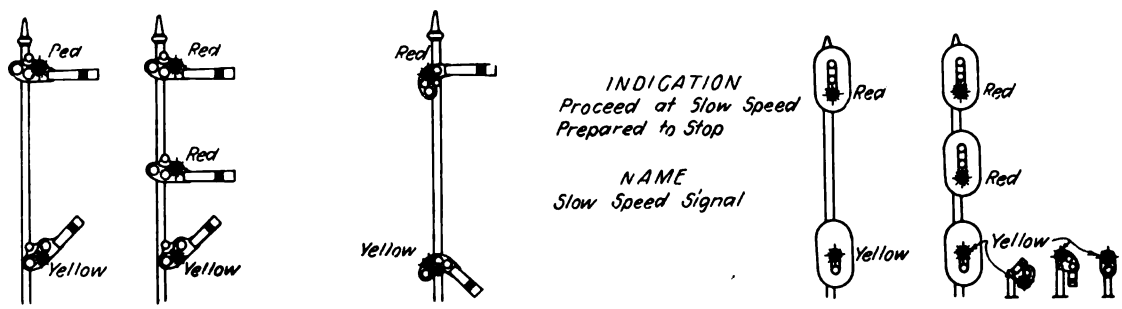


Three-Position Home Interlocking Signal Indications on the Chicago, Rock Island & Pacific





Three-Position Home Interlocking Signal Indications on the Chicago, Rock Island & Pacific

signal it stands at the entrance to a block, while at interlocking plants it stands from 5 ft. to 55 ft. or more in the rear of the switches, derails and clearance points which it protects. A home signal in an interlocking or a home block signal of a manual or controlled manual system, when in the stop position must not be passed, except on receipt of the proper authority from the leverman or block operator, either written or by flag. An automatic home block signal in the "stop" position indicates "stop, wait a specific length of time and proceed cautiously until a clear signal is encountered." In a single track automatic territory a flagman is generally required to be sent ahead to flag the block. When in the "clear" position it indicates "proceed."

Semaphore blades for home signals in two-posi-

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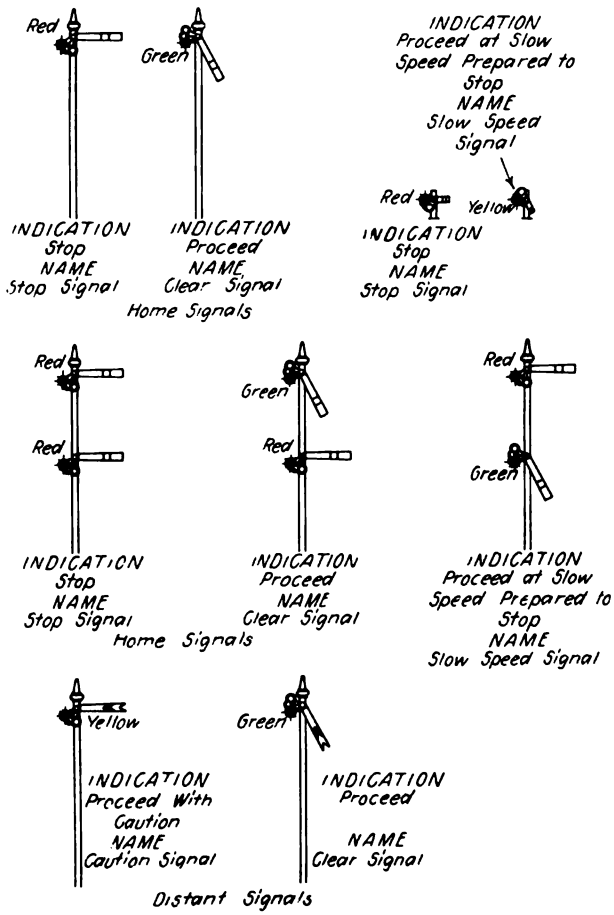
tion lower quadrant signaling are usually made with square ends to distinguish them from distant signal blades which usually have forked or "fish tail" ends. On many roads a further distinction is made by using blades with pointed ends for automatic home block signals and with square ends for all other home block signals.

In three-position automatic block signaling the functions of the home signal and the distant signal



Two-Position Interlocking Signal Indications on the Chicago, Rock Island & Pacific

are combined in a single arm. The term home signal was originally applied on British railways to the signal mounted on or near the signal box controlling the entrance of trains into a block section. See Signal, Distant. Also Signal, Advance. Also Signal, Dwarf. Also Signal Colors, Night. Also Signal, Starting. Also Block Signal System, Automatic. Also Signal Post.

SIGNAL, POT. A low revolving signal, turning on a vertical axis and used either as a switch target to indicate the position of the switch or derail to which it is attached or as a dwarf signal for low speed movements at interlocking plants. (The dwarf semaphore signal has now generally superceded it for the latter purpose.)

The pot signal consists of a lamp with either two or four lenses, two lens lamps being used for dwarf signals and four lens lamps for switch targets. The faces of the lamp, usually flaring discs, are painted colors corresponding to the lenses, the discs thus giving the day indications. Such signals are used in tunnels and yards where there is not room for semaphores. See Signal Colors, Night. Also Signal, Dwarf.

SIGNAL, POWER OPERATED. A signal actuated by some source of power other than mechanical. Power-operated signals may be of the ground, bridge, bracket or dwarf types and operated by electric, pneumatic or other agency. See Interlocking, Power. Also Block System.

SIGNAL, SEMAPHORE. A type of fixed signal consisting of an arm approximately four feet long and tapering from 7 in. in width where attached to the spectacle casting to about 10 in. at the outer end, mounted on a post, usually of iron, from 24 to 33 ft. high or on a shorter post supported on a bridge or other structure above the track. The pivot of the arm is combined with a spectacle casting holding colored glass discs which move in front of a lamp mounted on the post as the position of the arm is changed. The arm may be operated mechanically or by some source of power. It is used to convey an indication of the condition of the track ahead to the engineman and it is usually located at one side of or above the track it governs.

A semaphore arm gives its day indication by form and position independent of its color. The arm, however, is painted or enameled some color which will be visible for the greatest distance against the surrounding background. Red and yellow are the two principal colors used for this purpose, while white or black is used on the back side and edges of the blade. The Railway Signal Association specifies that blades for upper quadrant signals shall have the front painted red with a white stripe or yellow with a black stripe and that the back and edges shall be painted black. Some roads use red for home signals and yellow or green for distant signals; others use yellow for all blades, while still others use red and on one road at a number of locations the entire blade is painted black.

This type of signal was introduced on railways in England about 1841 and is now used almost universally in North America for both block and interlocking signals. See Signal Colors, Night.

SIGNAL, SEMI-AUTOMATIC. A signal having both manual and automatic control in connection with its operation.

It is controlled automatically through the medium of the track circuit and can only be cleared by the leverman or block operator when the track circuit is unoccupied. It can be placed in the "stop" position either by the leverman or block operator or by a train entering the track circuit controlling it. Semi-automatic signals may be mechanical signals equipped with electric slots or power-operated signals. Generally when these signals are put to the stop position automatically at interlocking plants it is necessary for the leverman to place his lever normal and again reversing it with the track circuit unoccupied before it can again be cleared. These signals are used in block signal territory. See Slot, Electric. Also Block Signal System.

SIGNAL, SLOTTED. A signal in which the connection from the lever or other operating mechanism is controlled by a mechanical or electric slot.

A slotted signal is used in connection with controlled manual blocking and on certain mechanical

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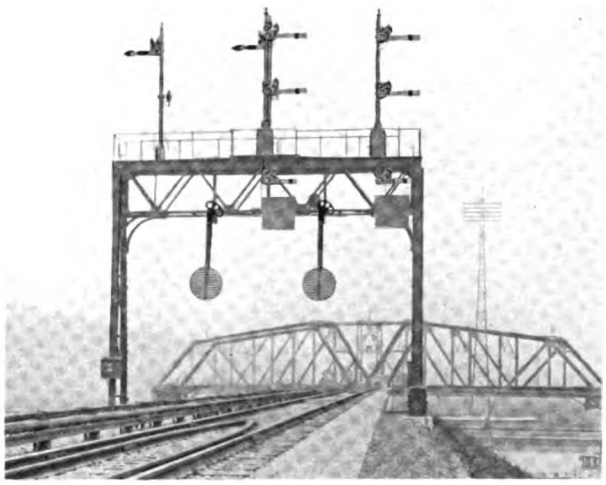
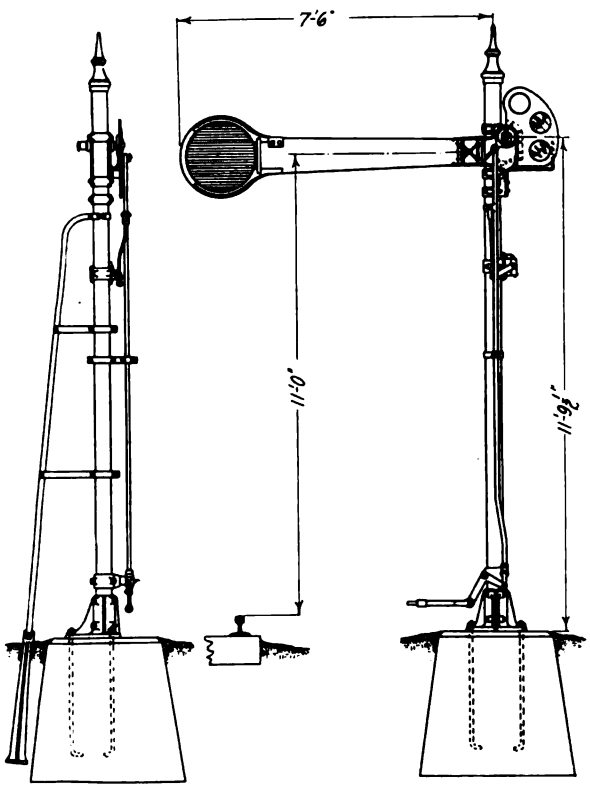
signals at interlocking plants in automatic signal territory, and on power interlocking plants. All automatic block signals are slotted signals. See Slot, Electric. Also Slot.

SIGNAL, SMASH. A signal of special form used at the approach to dangerous locations which, when in the stop position, fouls the smokestack or the



Smash Signal at Drawbridge Location

window of a locomotive cab in order to call an engineman's attention to danger ahead if he should otherwise fail to observe it.



One-Arm Pipe Connected Smashboard Signal with Night Indication
The Union Switch and Signal Co.

This form of signal is used at such locations as drawbridges and is usually some kind of obstruction, such as a long semaphore arm or a large disc which, when in the stop position, will foul the locomotive. If a train passes such a signal in the stop position the "smash" will call the engineman's attention and will leave a mark on the engine or train. As the signal will also be broken this affords a double check on its observance.

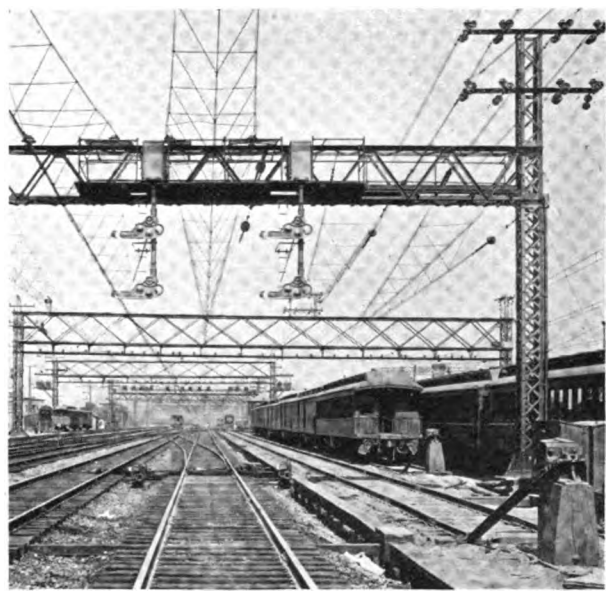
SIGNAL, SOLENOID. A high semaphore or dwarf power signal whose operation is dependent upon the action of a solenoid instead of a motor or other form of operating apparatus.

Some high semaphore signals of this type are used in connection with third rail electric systems, the solenoids obtaining their power from the third rail. A solenoid dwarf signal is used in connection with some electric interlockings. The solenoid, when energized, actuates a rack and pinion movement which operates the dwarf semaphore arm. See Solenoid.

SIGNAL, STARTING. The term used to designate the signals at the outer end of a train shed in a terminal or at the outgoing end of a side track.

Signals of this character are not used to a great extent in the United States, but in Great Britain it is common practice to have three stop signals in succession at a block station, called respectively the home, the starting and the advance starting signals. These signals are spaced far enough apart to allow an ordinary train to stand between the home and the starting signals and between the starting and advance starting signals.

SIGNAL, SUSPENDED. A signal hung from an overhead signal bridge or other high structure. Sig-



Suspended Signals on an Electrified Railroad

nals of this type are used in electrified and terminal territory and as starting signals at the leaving ends of terminal stations.

SIGNAL, THREE-POSITION. A semaphore, position-light or color-light signal, arranged to give three different indications.

In manually-operated signals of the semaphore type these indications may be given in three ways in the lower quadrant; (1) arm horizontal, "stop"; arm inclined downward 37½ deg., "caution" (per-

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missive block signaling); arm inclined downward 75 deg., "proceed," speed not limited; (This is but little used and is not in line with present-day practice.) (2) arm horizontal, "stop"; arm inclined downward 45 deg., "caution"; arm inclined downward 90 deg., "proceed," speed not limited. (3) The same indications as in (2), except that the arm is inclined upward in the upper quadrant. On a few roads the arm is designed to operate in both upper and lower quadrant positions in manual block signaling, the arm in the horizontal position indicating "stop"; inclined upward 45 deg., "caution"; inclined downward 45 deg., "proceed."

The present practice on steam roads is to operate the three-position signal in the upper right-hand quadrant. In automatic block signal territory where this type of signal is used the A. R. A. designates the indications as arm horizontal, "stop," then proceed under control, block is not clear; arm inclined upward 45 deg., approach next signal prepared to stop, block is clear, second block in advance is not clear; arm inclined upward 90 deg., proceed, two or more blocks are clear. At interlocking plants the indications are, arm horizontal, stop and stay, block (or route) is not clear; arm inclined upward 45 deg., approach next signal prepared to stop, block is clear, second block in advance is not clear; arm inclined upward 90 deg., proceed, two or more blocks are clear. This is applicable where interlocking signals are a part of the automatic block signal system on a railroad.

In automatic block signaling and at interlockings the indications are obtained by the position of the lights in position light signaling and by the color of the light in color-light signaling, red being the

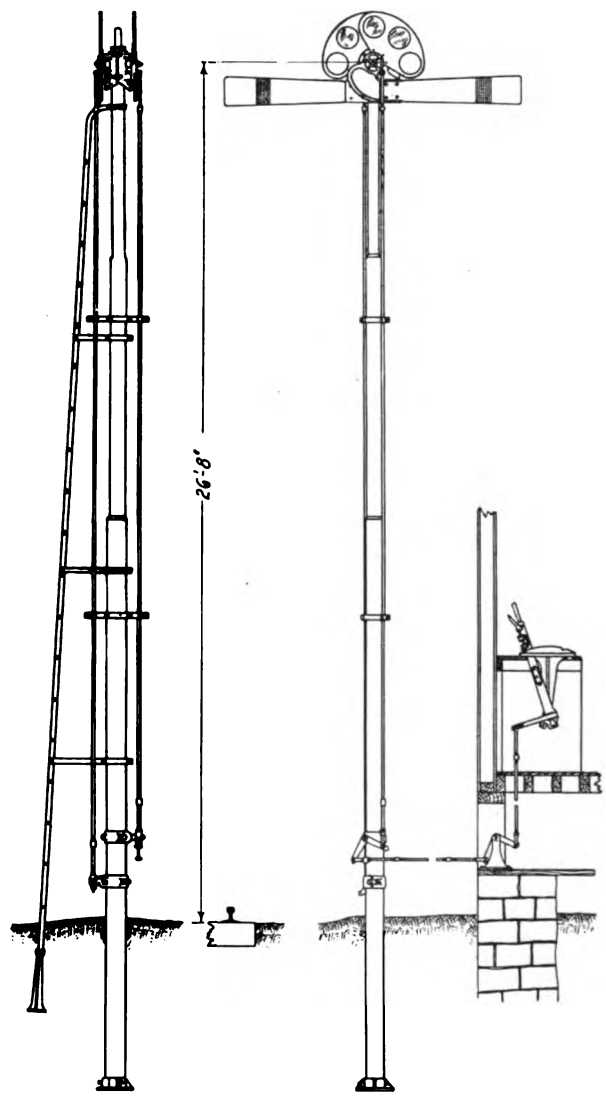
Two-Arm Color Light Interlocking Home Signals
The Federal Signal Co.

stop indication; yellow corresponding to the 45 deg. indication and green corresponding to the 90 deg. indication. Automatic and interlocking signals are distinguished from each other by some mark, such as the shape of blade, the position of a marker light, the use of a number plate, etc.

In addition to the above indications an approach restricting signal is sometimes used on some roads in interlocking and automatic territory and clear restricting signal at interlockings. The approach restricting signal is given by the top arm being inclined upward 45 deg. and the lower arm inclined upward 90 deg., and the indication means approach next signal at restricted speed, two block are clear.

The clear restricting signal is given by the top arm in the horizontal position and the second arm inclined upward to the 90-deg. position and the indication means, proceed at restricted speed, two or more blocks are clear. The approach and clear restricting signals indications are also given by position light signals. The slow speed arm at an interlocking or a tonnage signal on an automatic signal inclined upward to the 45-deg. position is a permissive signal indicating proceed at slow speed prepared to stop short of train or obstruction, block is occupied or switch is set to diverge. See Blade, Semaphore. Also Signal Colors, Night. Also Slow Speed (Calling On) Arm.

SIGNAL, TRAIN ORDER. A fixed signal of semaphore or other type, used at a telegraph or telephone station to indicate to a train whether or not it will receive orders at that station which will affect its rights to the main track.



Typical Train Order Signal Installation

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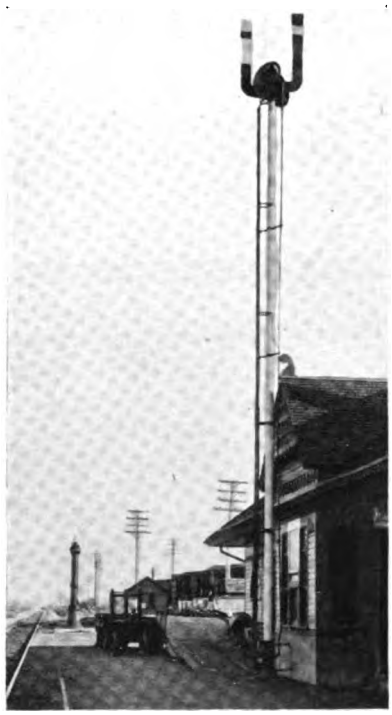
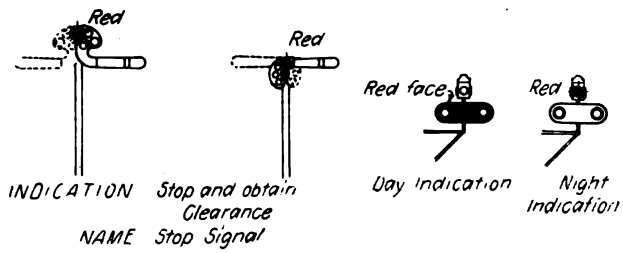
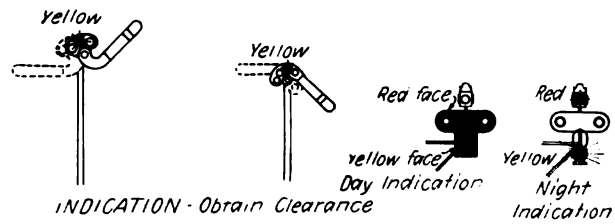
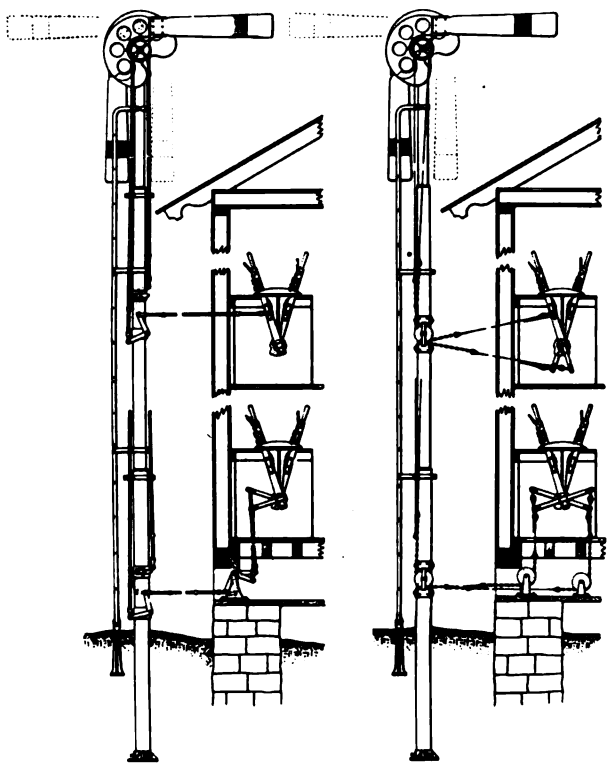
With the semaphore type, the indication may be given in either two or three positions, upper or lower quadrant. When a three-position indication is employed, the 45-deg. or "caution" position usually signifies that a "19" order is to be received which can be delivered without the necessity of a train stop, while the horizontal or "stop" position indicates a "31" order, requiring the train to stop, as those to whom the order is addressed, excepting the engineman, must sign it. In the two-position indication, the blade horizontal means either a "19" or a "31" train order, no advance information being given to the trainmen. Some train order signals are of the banner type, and when the banner (generally made of sheet iron, painted red and attached to a vertical spindle with a lamp support and mounted on a horizontal member) is turned with its face towards an approaching train it indicates a train order is to be delivered while when the edge only is showing no train orders are on hand. On a few roads flags (generally metal), for the day and lanterns of proper color for night are placed in a certain designated location to show that an order is to be delivered.



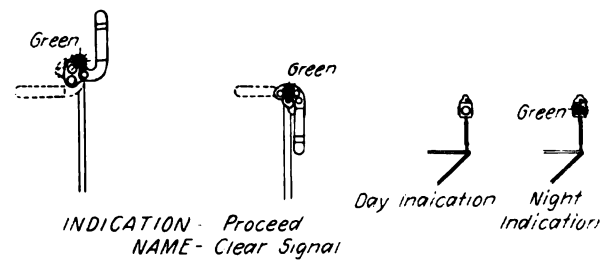
Train Order Signal Operated in the Upper Quadrant







Lower Quadrant Train Order Signals, Showing Details of Pipe and Wire-Operated Types



Train Order Signal Indications on the Chicago, Rock Island & Pacific

Train order signals are usually manually operated, but in the selective telegraph or telephone train dispatching system, the signal is controlled by a selector operated over the telephone or telegraph circuit by the dispatcher from a distant point. It is equipped with an answer-back mechanism, which indicates over the circuit to the dispatcher that the board or signal is set in the "stop" position. The board cannot then be set in the clear position without the

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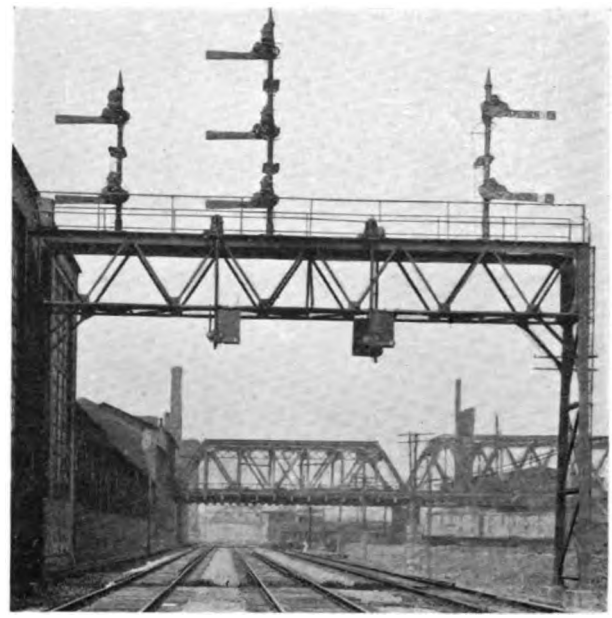
consent and co-operation of the dispatcher. See Signal, Three-Position. Also Signal Colors, Night.

SIGNAL, TUNNEL. A signal designed for use in tunnels. A colored light signal is usually employed for this purpose, the indication as to the condition of the block being given by the color of the light. Because of the reduced clearances this type of signal is well adapted to such locations. A pot signal is sometimes used as a tunnel signal. See Signal Colors, Night. Also Signal, Pot.

SIGNAL ASPECTS, TWO-LIGHT (system of). An arrangement of semaphore signals, in which every signal shows at least two lights at night. For example, a signal where there is a main route and a diverging route will have two lights as at an interlocking location. At a block signal where no diverging route is to be signaled, the second or lower light (never indicating proceed) is of use to assist the engineman in reading the upper one quickly. A second arm may be used as well as a second light to give the desired aspect by day as well as by night.

SIGNAL BRIDGE. A bridge designed especially for the support of signals above the tracks, used extensively on roads with multiple tracks in automatic signal territory in order that each signal mast may be placed above the track which it governs. Signal bridges are used to some extent on double track lines and frequently in yards where there is not sufficient clearance to place masts between tracks. They are of several different designs, one or two signal masts being cantilevered over certain tracks in some cases while in other places a complete bridge is built over the entire number of tracks, several of which may not require governing signals.



Signal Bridge for Three Tracks

Bracket masts are sometimes employed instead of signal bridges for three or four main tracks in automatic signal territory.

Cantilever Signal Bridge

SIGNAL COLORS, NIGHT. The colored lights by means of which signal indications are given at night except in the case of the position light signal in which the position of a beam of light furnishes the indication.

The number of possible signal colors is small, being limited to a few which stand out prominently to the eye. These colors are red, yellow, green, white, purple and blue. It is necessary that the night colors have about an equal range for the type of illumination used (oil, electricity or gas). The red, yellow and green have a range of from about 2½ to 3 miles under favorable conditions, purple has a range of about ½ mile under good conditions, blue has a range of about 1 mile although at ½ mile or over, according to Dr. Churchill, it has a tendency to assume a greenish tint and as it is weak in range and indistinct in hue it is of little or no use for a signal indication.

Purple makes a good short range signal indication for dwarf signals governing slow speed moves through an interlocking. Smoke, fog, haze and other atmospheric conditions have tendencies to shift the color indications of all signal lights towards red which tends to safety.

Prior to 1899, white was used extensively for clear, green for caution and red for stop but since that time green for clear, yellow for caution and red for stop have in large measure superceded the white-green-red combination because of the ever present danger that if a colored lens or roundel is broken a clear signal indication will result, until at present only

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about 21 per cent of the railway companies reporting use white for clear. In order to reduce the range of a dwarf signal indication a number of railways have abandoned red and substituted purple for this indication. This gives a distinctive light at night for the stop indication of low speed signals different from that used on high signals.

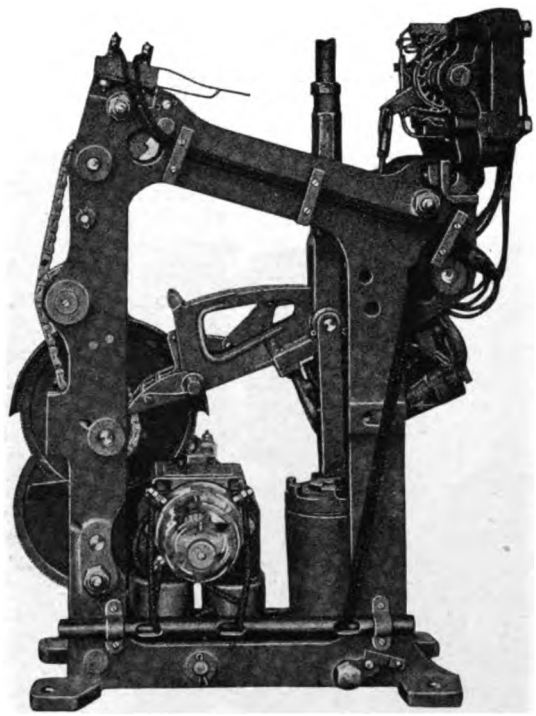
SIGNAL MAST. The upright support to which the signals are directly attached.

Signal masts generally are of built up or tubular steel, although in some cases as at distant switch signal or distant signal locations on mechanical plants wooden masts are used. However wooden masts are in disfavor because of their relatively short life and their tendency to warp or turn, thereby throwing the signal blade or signal light out of the direct line of vision of an engineman and interferring with the signal indication.

The tubular iron signal masts specified by the R. S. A. for power signals with mechanism at the semaphore shaft and for mechanical signals with pinnacle and base castings are respectively 7 ft. 8 in.; 20 ft. 8 in.; 26 ft. 8 in.; 33 ft. 8 in.; and 39 ft. 8 in. high, the last three are made of two sections of pipe, the lower of 6 in. diameter and the upper of 5 in. diameter, while the first three are made of one length of 5-in. pipe. The three shorter lengths are used on signal bridges and bracket posts, while the longer length masts are employed for ground signals. See Bracket Mast. Also Bracket Post. Also Bridge Mast.

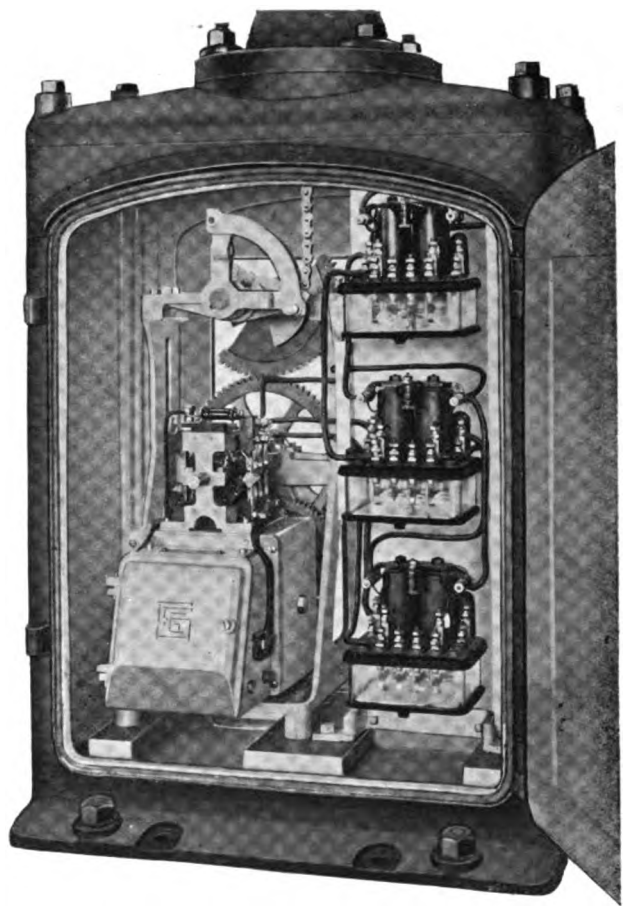
SIGNAL MECHANISM. The apparatus of a power-operated signal which directly operates the semaphore arm or disc of the signal.

Signal mechanisms may be classified as of the top-of-mast or base-of-mast type, depending upon whether they can be clamped to the post for operat-



Base-of-Mast, Electric Semaphore Mechanism
The Union Switch and Signal Co.

Base-of-Mast, Electric Semaphore Mechanism
The General Railway Signal Co.



Base-of-Mast, Electric Semaphore Mechanism
The Federal Signal Co.

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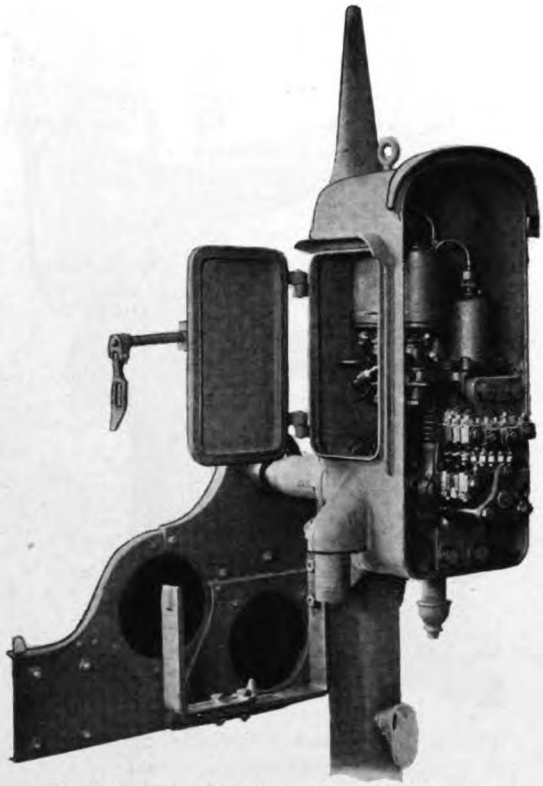
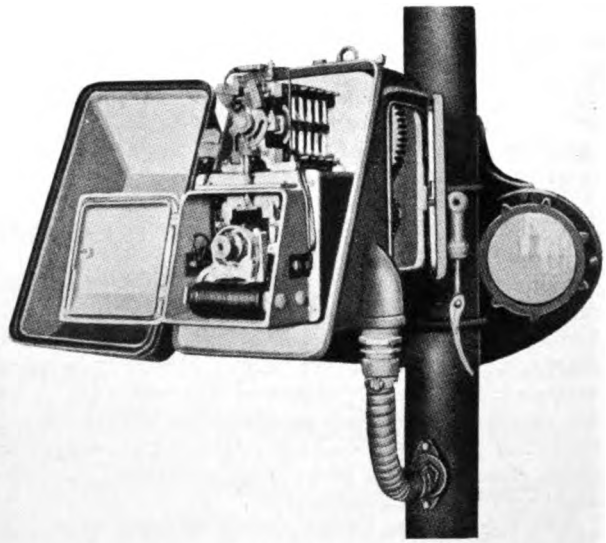
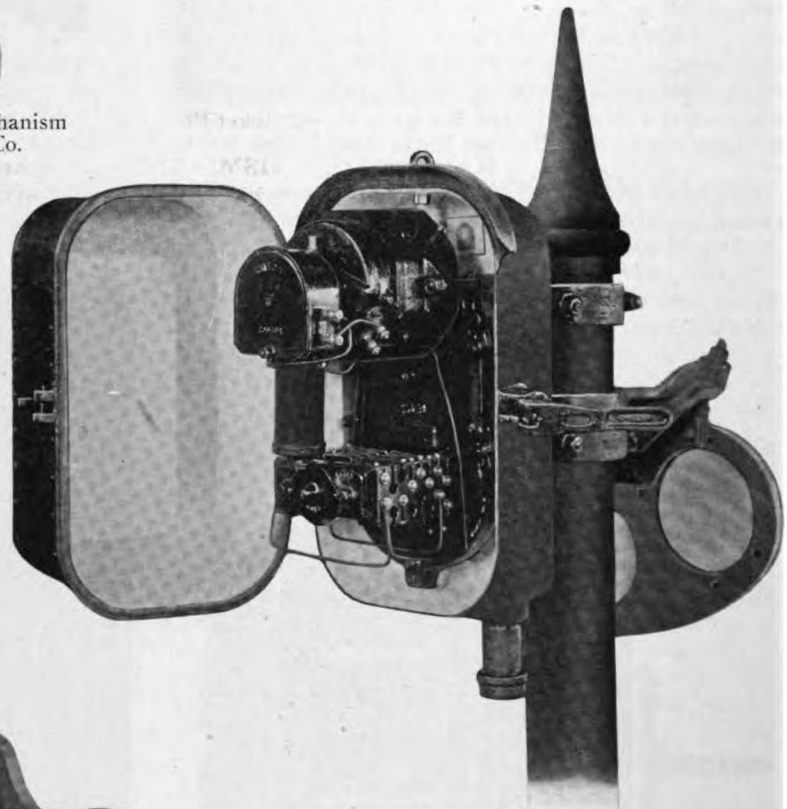


Electro-Pneumatic Semaphore Mechanism
The Union Switch and Signal Co.

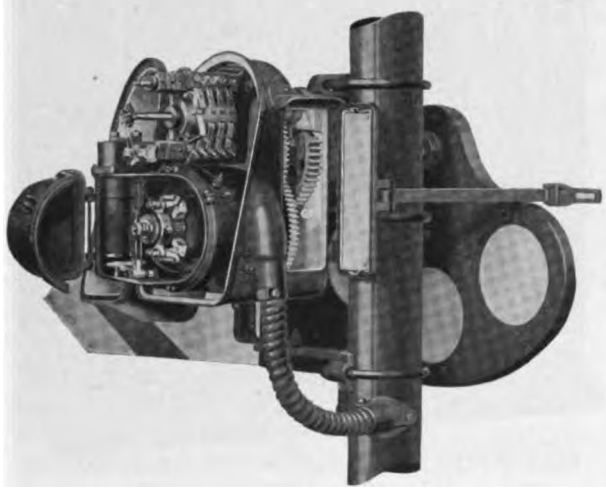


Top-of-Mast, Electric Semaphore Mechanism
The Federal Signal Co.

ing the semaphore arm and directly attached to it or are contained in a case at the base of the mast and operate the arm by means of a vertical rod. The mechanism for electrically-operated signals consists of an electric motor with its necessary chain of gears, circuit controllers and slot, while the electro-pneumatic or electro-gas mechanism is essentially a piston and cylinder with its control valves and electro-magnets. In disc signals, the clock-work or electro-magnetic



Top-of-Mast, Electric Semaphore Mechanism
The Union Switch and Signal Co.



Top-of-Mast, Electric Semaphore Mechanism
The General Railway Signal Co.

mechanism which operates the disc is spoken of as the mechanism; while the light units in light signaling are considered as the mechanism.

SIGNAL POST. See Signal Mast. Also Ground Signal Post.

SIGNALS, THREE-POSITION AUTOMATIC BLOCK. A system of automatic block signals designed to provide the protection of distant signals

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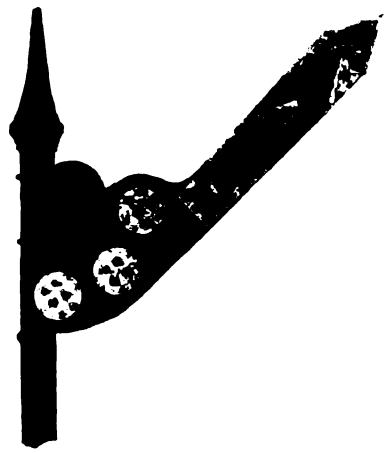
without the duplication of signal arms usually involved.

Each signal arm is so arranged that it may assume any one of three positions; horizontal for "stop"; inclined 45 deg. in either the upper or lower quadrant, "caution"; inclined upward or downward in the vertical position, "proceed." The signal goes to the stop position when a train enters the block; when the train clears the block it moves to the 45-deg. position and remains in that position until the next signal in advance moves to the caution position, when it then goes to the 90-deg. or "clear" position. Thus a train is always protected by a stop signal in the rear and a caution signal one block further back. Three-position automatic block signals were introduced first on the Pennsylvania Lines, west of Pittsburgh, in 1900. See Signal, Three-Position. Also Signal Colors, Night.

Automatic Signal Arm at Stop



Automatic Signal Arm at Caution

Automatic Signal Arm at Clear

Three-Position Color Light Signal

SLOT. A disconnecting device inserted in the connection between a signal arm and its operating mechanism.

Where it is desired to control one signal from two interlocking machines mechanically, a mechanical slot may be used. In its old English form the "slot" consisted of rods with long slots cut in them. The slot is used to put a signal in the stop position regardless of the action or inaction of the leverman in charge. With the slot arrangement a given signal can be put in the stop position by either of two levermen, but it cannot be put in the clear position except by the co-operation of both.

Slots are of two general types, mechanical and electro-mechanical. The mechanical type is used where it is desired to control one signal mechanically from two interlocking machines. This slot consists of two vertical rods moving in guides in a casting so arranged that it is necessary for both to be raised in order to clear the signal arm, and is practically obsolete. The electro-mechanical slot (when separate from the signal operating mechanism) is placed in the connection between a signal arm and its operating mechanism in order to insure that a signal will indicate stop even though the lever to which it is connected may not have been restored to the normal position after the passage of a train, thus preventing other trains following on the same clear indication. It is used in connection with controlled manual block signaling and at mechanical interlocking plants in automatic signal territory. See Slot, Electric.

SLOT, ELECTRIC. A device in which the connection between a signal arm and its operating mechanism is controlled by an electric magnet, the connection being broken when the magnet is de-energized, and established when the parts are in proper mechanical relation and the magnet energized.

The electric (or electro-mechanical) slot is commonly used in semi-automatic block signaling to

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prevent the clearing of a signal, or to cause it to assume the stop position when the route or track section is obstructed. In telephone train dispatching it is used to prevent the clearing of the signal without the consent and co-operation of the dispatcher. See Signal, Semi-Automatic.

SLOT, SPINDLE. An electro-mechanical slot attached to the semaphore shaft of a signal to perform the same function as an electric slot.

A slot of this type is employed on mechanically-operated signals, such as on home signals at interlocking plants, in order that they may operate as semi-automatic signals where this feature is desirable at such locations. The slot is controlled by a track circuit which, when a train enters it, causes the slot circuit to be opened, allowing the signal arm to assume the "stop" position. By the use of an electro-mechanical slot a leverman is required to clear the signal for every train movement, thus preventing him from leaving it in the clear position after the passage of a train. See Slot, Electric.

SLOW SPEED (Calling On) ARM. A semaphore signal arm used to authorize a train to move past a home signal when the high or the medium speed arm cannot be cleared because the block section governed by it is occupied or if for any reason a train should not be permitted to pass the home signal unconditionally.

The slow speed arm has a signal blade 2 ft. 6 in. in length as compared to the standard 3-ft. 6-in. signal blade. This arm is placed on the signal mast below the standard size arm or arms. The slow speed indication is given by this arm being inclined to a 45 deg. position in the upper or lower quadrant. It may govern any route and is used for the purpose of permitting greater freedom of train movement. It ordinarily is not connected with the track circuit, so that in the event that it is desired to move a train following one in advance this may be done by the indication of this signal, authorizing a train to move at slow speed prepared to stop. It is used at interlocking plants to facilitate train movements through the plants.

SOLENOID. A cylindrical coil of wire with a few or many turns and an iron plunger which fits into the inside of a coil, the iron plunger being attracted when current is passed through the coil. This is one of the simplest types of an electro-magnet.

Solenoids used in signals are designed to exert the proper pull on the plunger, which, through proper connections, operate the semaphore arms. Pender states that the pull of the simple solenoid varies between approximately zero when the plunger is at the lower end of the coil and a maximum which is nearly constant over approximately forty per cent of the length of the coil and that the maximum is reached when the plunger has entered the coil a distance of approximately forty per cent, but that the pull decreases after the plunger has entered eighty per cent of its length, reaching a value of about 0.6 of the maximum pull when the plunger is even with the top of the coil.

SIGNALING PRACTICE. The essentials of signaling as outlined to guide general practice. A memorandum on the essentials of signaling was drafted by the R. S. A. and incorporated in the report of the Committee on Transportation of the American Railway Association in May, 1911. The memorandum as adopted by the R. S. A. is as follows:

"The reports of various committees of the Railway Signal Association and of the American Railway Engineering Association on the subject of signaling have been submitted to this committee, with the request that the essentials of signaling be outlined or defined for the future guidance of their committees.

"The subject has been carefully analyzed and considered. There are three signals that are essential in operation and therefore fundamental, viz.:

(1) Stop.
(2) Proceed with Caution.
(3) Proceed.

"The fundamental, 'proceed with caution,' may be used with the same aspect to govern any cautionary movement; for example, when:

(a) Next signal is 'stop.'
(b) Next signal is 'proceed at low speed.'
(c) Next signal is 'proceed at medium speed.'
(d) A train is in the block.
(e) There may be an obstruction ahead.

"There are two additional indications which may be used where movements are to be made at a restricted speed, viz.:

(4) Proceed at low speed.
(5) Proceed at medium speed.

"Where automatic block system rules are in effect, a special mark of some distinctive character should be applied at the stop signal.

"The committee therefore recommends:

SIGNAL FUNDAMENTALS

(1) Stop.
(2) Proceed with caution.
(3) Proceed.

Supplementary Indications to Be Used Where Required

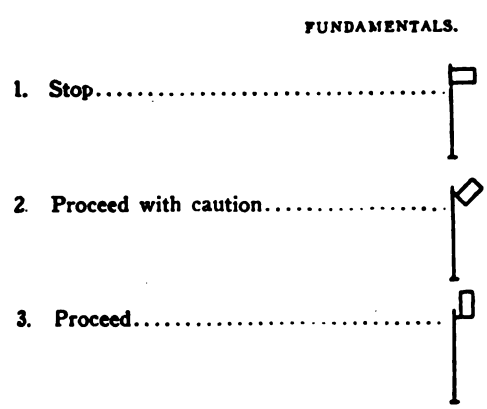
(4) Proceed at low speed.
(5) Proceed at medium speed.

"Stop signals operated under automatic block system rules should be designated by some distinctive mark to be determined by each road in accordance with local requirements."

RECOMMENDATION OF COMMITTEE I.

"The committee submitted for approval the following two schemes of signaling in conformity with recommendations of the Committee on Transportation.

Scheme No. 1—Fundamentals



"As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

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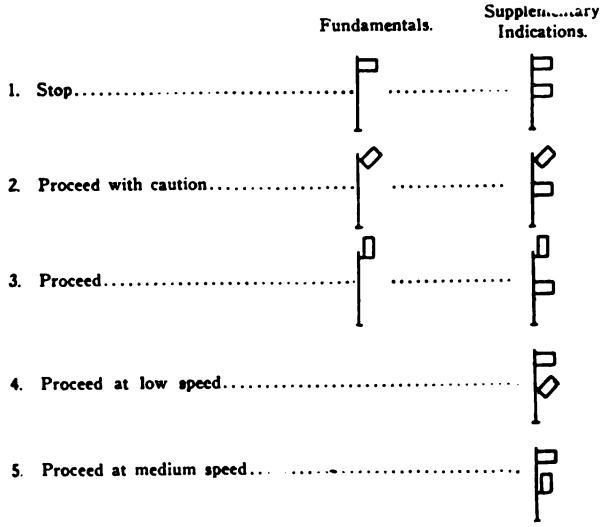
Scheme No. 2—Fundamentals. Supplementary

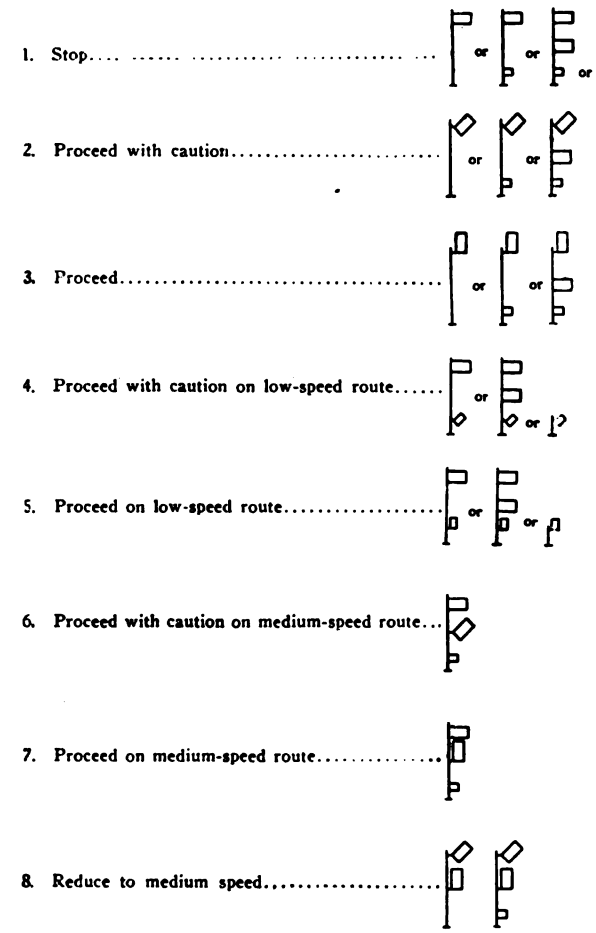


"As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

"Having in view the practice of indicating diverging routes by several arms on the same mast, the committee submits for approval the following to establish uniformity in this practice:

Scheme No. 3



"As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving stop indication having square ends; or
4. A combination of these distinguishing features.

"The above three schemes are submitted, after an earnest effort to carry out the committee's instructions to submit a uniform scheme of signaling, with the idea that each scheme is complete in itself."

SPACE INTERVAL SYSTEM. That system of train operation in which a space interval is maintained between trains moving in the same direction.

Block signaling is the basis of the space interval system, in which use is also made of the time table, train order, train order signal and train dispatching. Although trains are moved by time table and train order, the block signals enforce an interval of space between trains moving in the same direction, wholly regardless of the time interval. See Block System. See Time Interval System.

SPECTACLE (Semaphore). The part of the arm casting which holds the colored glass used to convey the night signal indication of a semaphore signal. See Arm Casting, (Semaphore).

STAFF. That part of the apparatus used in the staff system which is delivered to the engineman as his authority for the use of the block. See Electric Train Staff System.

STAFF CRANE. A post with suitable bars to support a staff.

This device is fixed near the track in the same manner as a mail crane to enable the enginemen of trains passing at moderate speeds to reach to the side and take the staff. Staff cranes also are made to receive staffs from moving engines. Staffs may be exchanged at high speed by having a suitable apparatus located on the locomotive for this purpose. See Electric Train Staff System.

STICK RELAY. A relay of the ordinary type so connected that its armature closes a circuit through its own coils; that is there are two paths provided for the current. A stick relay is used very extensively in connection with the design of certain signal circuits especially in connection with electric locking of the various types. It is also used under certain conditions in connection with highway crossing protection apparatus. Certain approach indicator and annunciator circuits make use of a stick relay. See Relay. Also Indicator, Approach. Also Annunciator. Also Locking, Electric. Also Locking, Stick.

SYMBOL, SIGNAL. A sign used on signal plans and drawings to designate the location and kind of apparatus to be employed.

The R. S. A. has adopted 13 plates of symbols to be used in connection with the preparation of signal plans and drawings. The first and second plates represent signal symbols; the third and fourth, location symbols; the fifth, track and duct run symbols, etc.; the sixth, track and leadout symbols; the seventh and eighth, relay, indicator and lock symbols; the ninth, lever circuit controller symbols; the tenth, signal circuit controller symbols; the eleventh, time

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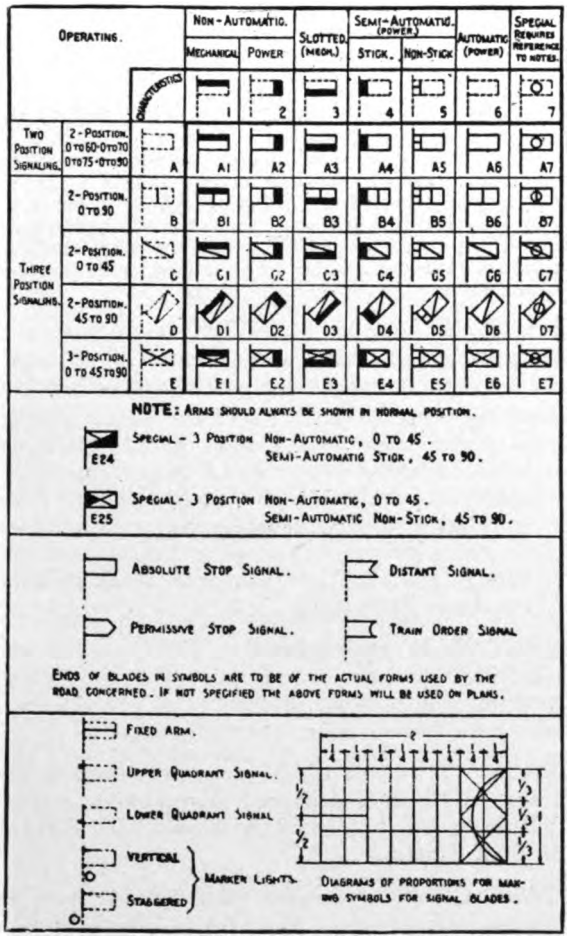

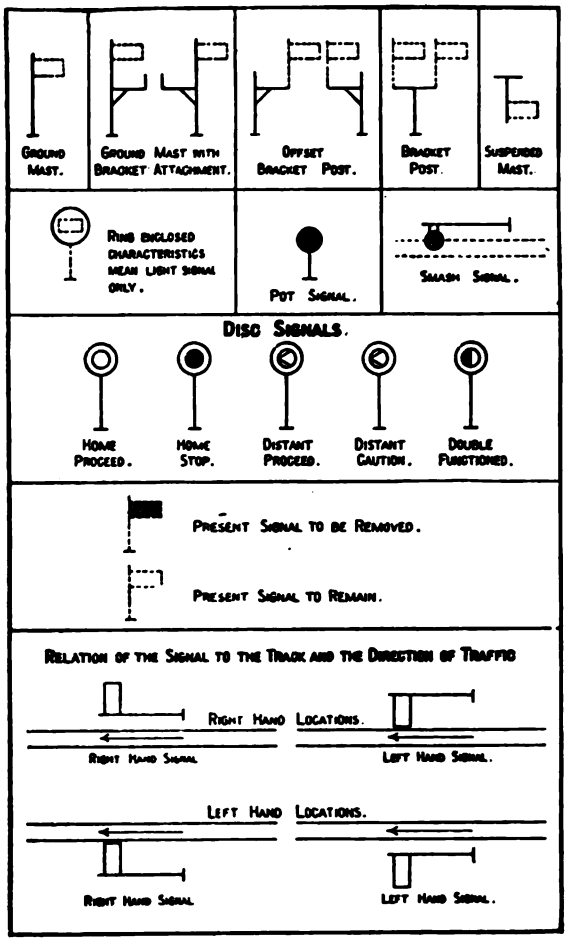

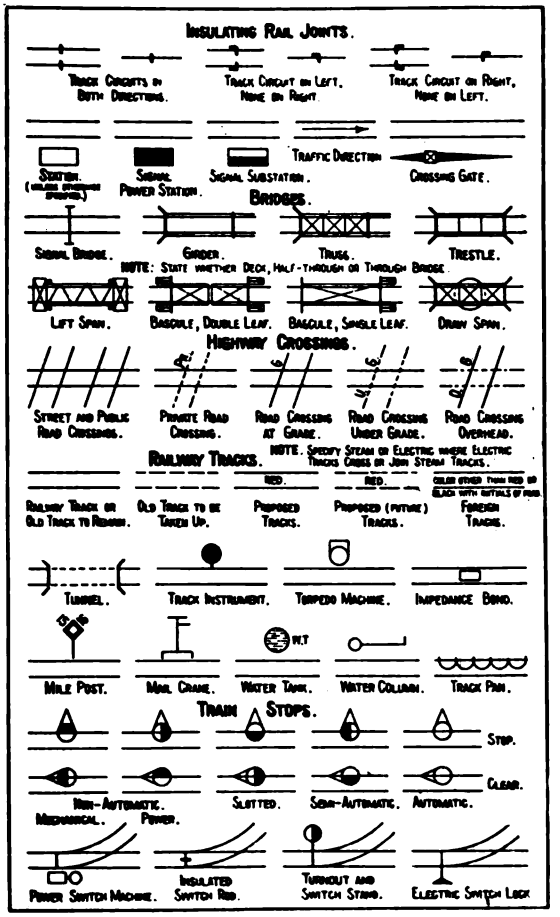

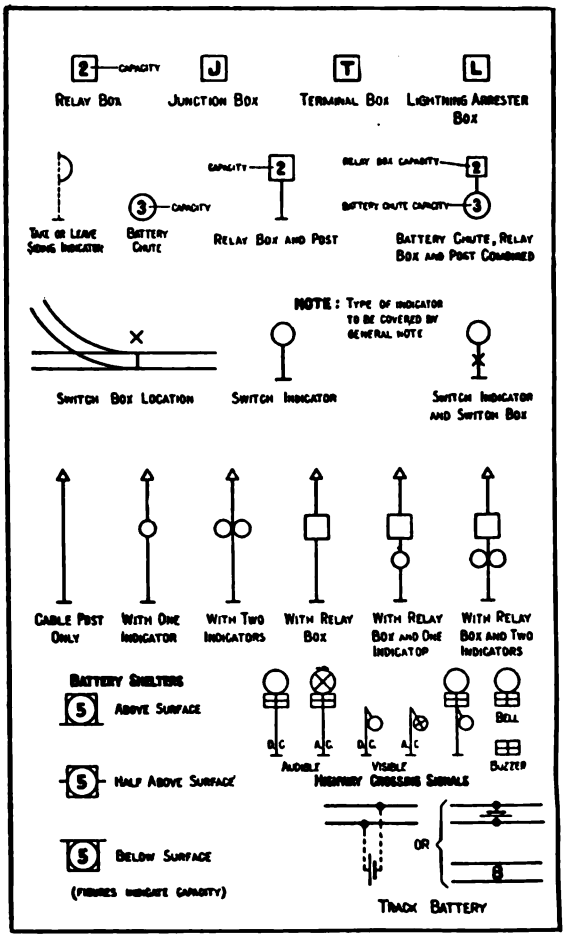

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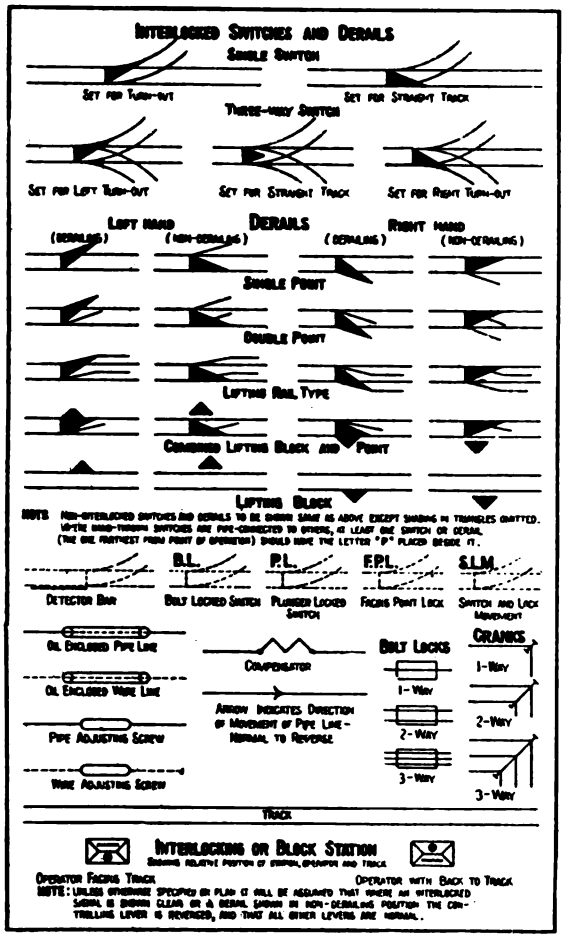

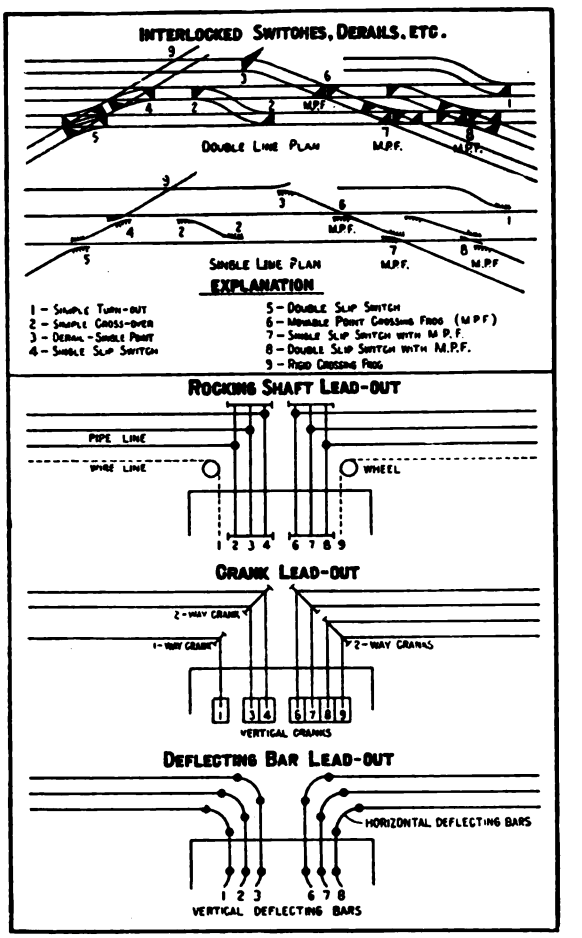

Relays, Indicators and Locks.

Elements of Symbols to be combined as necessary.

- D.C. Electro Magnet.
- A.C. Electro Magnet.
- Coil Energized or De-energized.
- Neutral Front Contact - Closed or Open.
- Neutral Back Contact - Closed or Open.
- Polarized Armature - With Contacts.
- 3-Position Armature - With Contacts.
- High Current Contact.
- Magnetic Blow-out Contact.
- Bell Attachment.
- Double Winding - Specify if Differential.
- Slow Acting..
- Disc Type Indicator. ○ = Disc Invisible. ● = Disc Visible.
- Semaphore Type Indicator. P = 3-Position.
- Wire Wound Rotor.
- Stationary Winding. ⊠ = High Voltage Winding.
- Electric Lock - Show Segments for Lever in Normal Position.

(See next page for examples of combinations.)

Relays, Indicators and Locks.

Examples of Combinations.

D.C. RELAY - Neutral - Energized -
One Independent Front Contact Closed -
One Independent Back Contact Open.

D.C. RELAY - Polarized - Energized -
Two Combination Front and Back Neutral Contacts -
Two Polarized Contacts Closed -
Two Polarized Contacts Open.

D.C. INDICATOR - Semaphore Type - Energized -
Three Front Contacts Closed -
Bell Attachment.

D.C. INDICATOR - Semaphore Type - Arm Horizontal -
Energized - Without Contacts.
NOTE: Indicators (or Repeaters) without contacts should be shown with armatures to indicate whether energized or de-energized.

A.C. RELAY - One Energizing Circuit Type (Single Phase)
Energized - One Front Contact.

A.C. RELAY - Two Energizing Circuit Type - Energized -
Wire Wound Rotor -
Two Neutral Front Contacts.

A.C. RELAY - Two Energizing Circuit Type - Energized -
Wire Wound Rotor -
Two Polarized Contacts.

A.C. RELAY - Two Energizing Circuit Type - Energized -
Stationary Windings -
One Neutral Front Contact -
Two 3-Position Contacts.

D.C. INTERLOCKED RELAY.

D.C. ELECTRIC BELL.

Designate resistance in ohms of all D.C. Relays, Indicators and Locks.

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Circuit Controllers Operated by Levers.

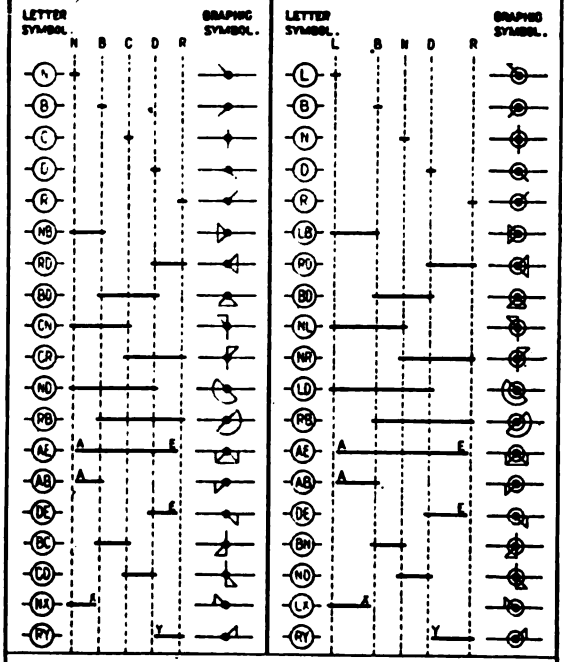
Use either Letter System or Graphic System.

Levers with Extreme End Position as Normal.

N - Full Normal Position of Lever
B - Normal Indication Position.
C - Central Position.
D - Reverse Indication Position.
R - Full Reverse Position.

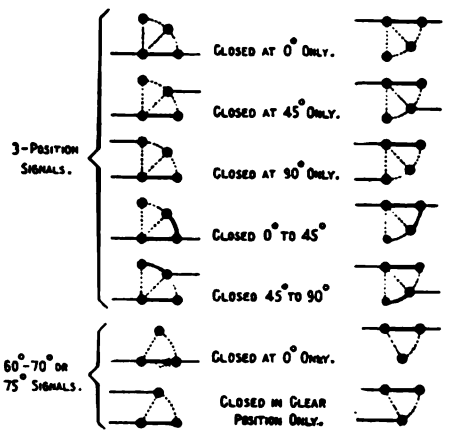
Levers with Middle Position as Normal.

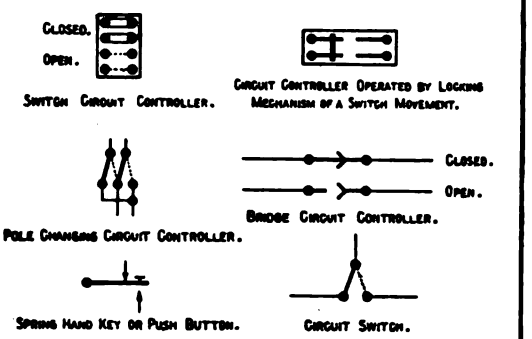
N - Normal Position.
L - Full Reverse Position to the Left.
B - Indication Position to the Left.
D - Indication Position to the Right.
R - Full Reverse Position to the Right.

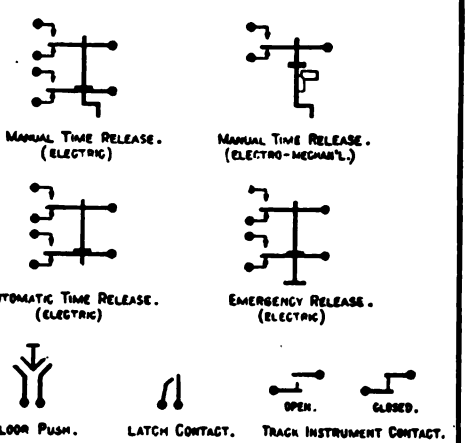


NOTE: Heavy horizontal lines indicate portion of cycle of lever through which circuit is closed.

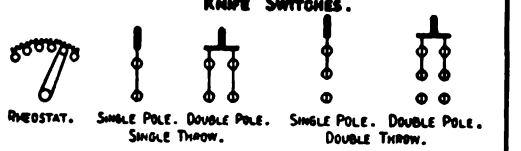
Circuit Controllers Operated by Signals.



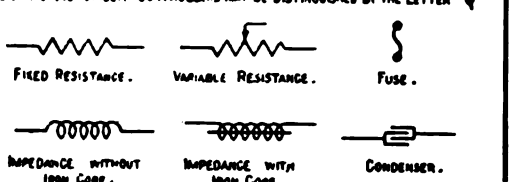




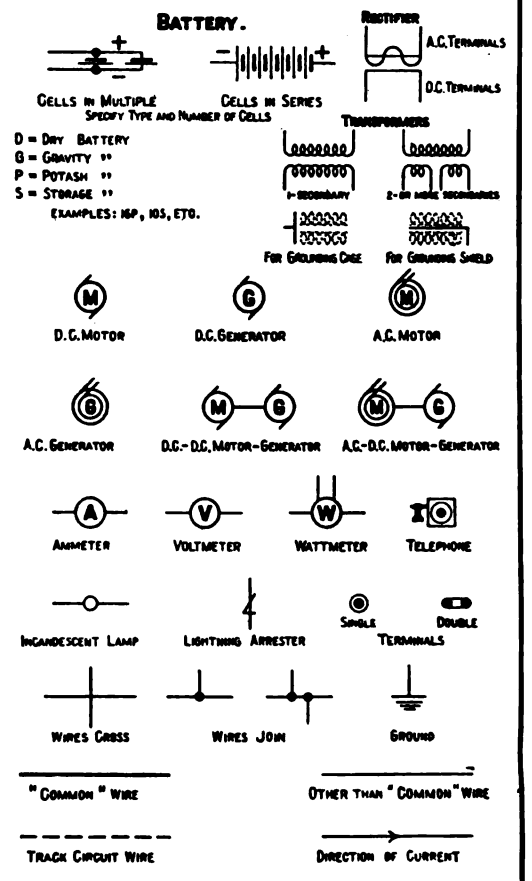
Knife Switches.



Quick Acting Circuit Controllers may be Distinguished by the Letter "Q"



Battery.



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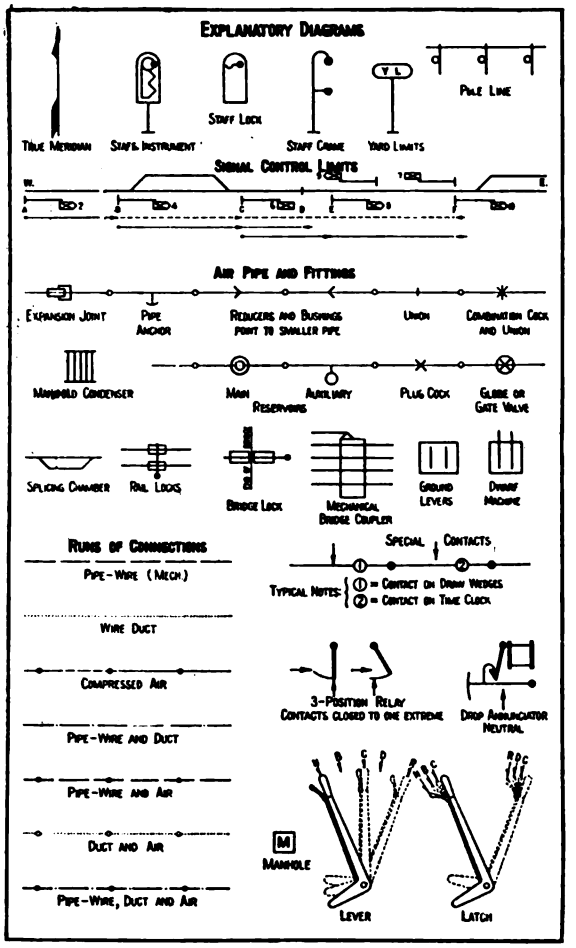


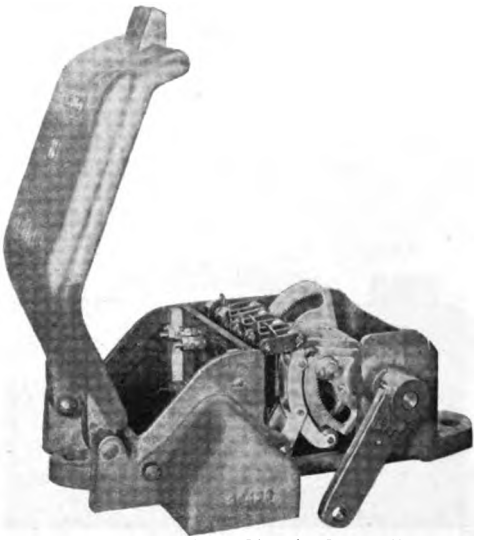
release symbols; the twelfth, battery, generator, wire crosses and joints symbols, etc.; and the thirteenth, explanatory diagrams, air and pipe fittings, runs of connections, etc.

SWITCH AND LOCK MOVEMENT. A device for the operation of a switch or derail by means of which a single stroke of a lever preforms the three operations of unlocking the switch, moving it and locking it again. This term is often abbreviated on plans and otherwise as S. L. M.

SWITCH BOX, (Also Called Switch Instrument). The familiar name for a circuit controller at a switch, which is contained in an iron box that is mounted on a long tie about three feet from the nearest rail of the track and is connected to the point of the switch by a rod. The opening of the switch makes or breaks an electrical contact in the box.

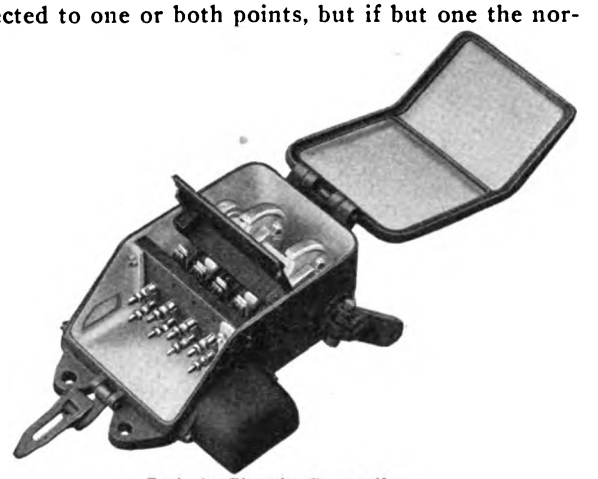
A switch box is used in automatic block signal territory for the purpose of short circuiting the track circuit, thus producing the same result upon the signal system as if a train was on that track section, if the switch should be open or if the switch point should lip open. In addition to short circuiting the track circuit many roads break signal line control circuits through the contacts of the switch box.

Some of the requisites of the R. S. A. are that switch boxes shall be so constructed that they can be maintained to make or break a circuit when the switch point shall be moved from the closed position 3/16-in. or other distance, depending upon the standards of the railway; operating rods of switch circuit controllers shall be not less than ¼ in. in diameter and adjustable with a maximum distance of 3 ft. between supports; circuit controllers for non-interlocking switches where a shunt is required shall have two independent shunt connections to the track circuit of each track affected by the opening of the switch, and shall shunt track when switch points



Universal Switch Circuit Controller
The Union Switch & Signal Co.

shall have been opened from the closed position $\frac{7}{16}$ in., or other distance in line with a road's standards; non-interlocked single main line switches, both ends of crossover switches and hand-operated siding derails shall be equipped with one switch circuit controller unless otherwise specified; the switch circuit controller shall be positively connected to one or both points, but if but one the nor-



Switch Circuit Controller
The General Railway Signal Co.

mally closed (or that determined by the road's standards) points shall be selected; switch circuit controllers used for selector purposes shall be insulated from the gage plate and from the track; plunger lock circuit controllers shall be used when specified; contacts for shunting connections shall be adjusted to spring closed and contacts for line connection shall be adjusted to spring open in addition to being mechanically forced each way.

This instrument is also used at interlocking plants for the proper selection of interlocking circuits.

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SWITCH INDICATOR. A device to indicate visually or audibly or both visually and audibly to a person preparing to throw a switch, whether a train has entered or is approaching the block in which the switch is located, and whether it is permissible to open the switch. The usual indications are given by an electrically-operated miniature semaphore arm or disc enclosed in a weatherproof metal case with a glass protected face and mounted on a post near the switch stand.

The apparatus consists of a pair of magnets and an armature to which is attached the small movable disc or miniature semaphore arm. Indicators are controlled by circuits in such a manner as to announce the approach of a train by the horizontal position of the arm, the presence of the disc, or, if an audible warning, by the ringing of the bell when

Switch Indicator
The General Railway Signal Co.

Switch Indicator
The Federal Signal Co.

a train is a certain distance away, usually when it is approaching the distant signal for the block which includes the switch. When an indicator announces the approach of a train, the switch must not be opened until the train has passed.

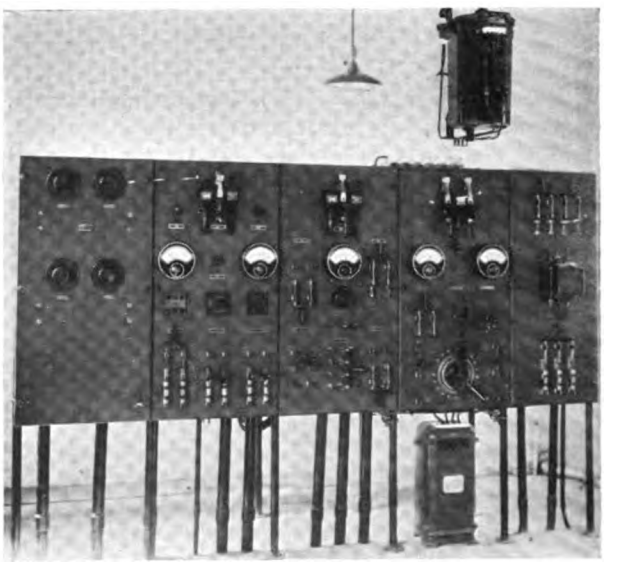
The switch indicator is an adjunct to the automatic block signal system and may be arranged to indicate whether a train is approaching; whether or not that portion of the block between the switch and the next home block signal in advance is clear, and whether or not the next home block signal in the direction of the approaching train indicates stop. Indicators are sometimes unnecessary and may be omitted at certain switches where signals are so located and controlled that the information which a switch indicator would give can be obtained from the signals themselves.

In the installation of switch indicators, the R. S. A. specifies that they shall be located preferably at main track switches connected with tracks on which trains may clear main tracks and in which either there are no derails or diverging switches, or the derails or diverging switches are connected with the main track switches; at points from which switches or crossovers between main tracks are operated or locked, where both switches are operated and locked from the same point; at independently operated switches of crossovers between main tracks, the indicator at the switch in one track operating in connection with the other track.

A separate switch indicator is to be used for each direction where indications are given relating to traffic in both directions on the same track. Switch indicators which cannot be identified by their locations must be marked with the designations of the tracks or the directions of traffic in connection with which they are operated.

Switch indicator circuits are to be so arranged that the indicator will warn of the approach of a train which has reached a point at least such a distance to the rear of the second block signal, located in the direction of the approaching train, that if the switch is thrown at a moment when the train reaches that point, the caution indication will be displayed in time for the engineman to observe and heed it. The switch indicator will continue to give an indication until the train passes the home block signal to the rear of the switch or approximately the clearance point of the switch when it is more than —— ft. in advance of the home block signal. The distance of the point at which the approach of the train is first indicated is to be determined in each case by the grade, speed of trains, view of signal or other local conditions. See Block Signal System, Automatic.

SWITCHBOARD. A slab of slate or marble on which are mounted the necessary switches, meters



Switch Board for Power Interlocking, Showing Service Panel, Rectifier Panel, Interlocking Panel, and Charging Switches

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and other apparatus required for regulating and controlling the electric current in a power house, substation or similar place. This apparatus is mounted

A Power Switch Board at a Power Interlocking

on the front of the switchboard, and the connections and bus bars are mounted on the back. Large switchboards are usually divided into a number of separate panels. See Interlocking, Power.

SWITCH, OUTLYING. A switch not connected with an interlocking plant. Such a switch may be locked by a key which is kept by the nearest leverman (which, however, causes too many delays on a busy line), or by an electric lock controlled from the nearest signal tower by electric circuits. In some cases where neither of these arrangements is in force, telephone communication is maintained between the switch and the nearest signal tower, so that trainmen desiring to use the switch can receive instructions from the leverman as to the use of the main track. See Lock, Electric Switch. Also Locking, Electric.

T

TAKE-SIDING INDICATOR. A device to indicate visually to an engineman that his train must take the siding at a non-interlocked switch.

A take-siding indicator can be used in connection with sidings used frequently for passing purposes and can be applied to any existing signal system. Such an indicator can be controlled by the dispatcher who can set the signal from his office, or by an operator at a station acting on instructions from the dispatcher. Its use reduces the number of "19" and "31" train orders required.

The take-siding indicator adopted by the R. S. A. consists of a No. 16 gage sheet steel face 18 in. in diameter, enameled primrose yellow with black letters bearing the words TAKE SIDING, 4 in. high. This face is attached to a ¾-in. by 1½ in. by 9-in. C. I. radial arm which is actuated by a power-operated mechanism or by mechanical means. The disc is displayed only when a train is to take siding and it may be illuminated at night by reflected or transmitted light.

Other devices designed to accomplish the same purpose are in use by different railways, the Michigan Central employing an enclosed disc signal case

Details of R. S. A. Take Siding Indicator

with a swinging disc for the day indication and a blinking yellow light at night. The Nashville, Chattanooga and St. Louis, and the Cleveland, Cincinnati, Chicago & St. Louis employ an enclosed disc signal case with a disc having the letter S displayed for the day indication to take siding, this letter being illuminated for the night aspect. The Atchison, Topeka & Santa Fe uses a short signal arm in the 45 deg. position and also displays the words "Take Siding," which are illuminated at night. The Missouri Pacific uses a second forked end arm on a signal mast which, when in the 45 deg. position by day or displaying a green light at night, indicates take siding, while the Pennsylvania uses no-glare lights by day and night for this purpose as well as a mechanically-operated "X" in conjunction with a yellow light. The Baltimore & Ohio and the Atlantic Coast Line use a yellow disc which is

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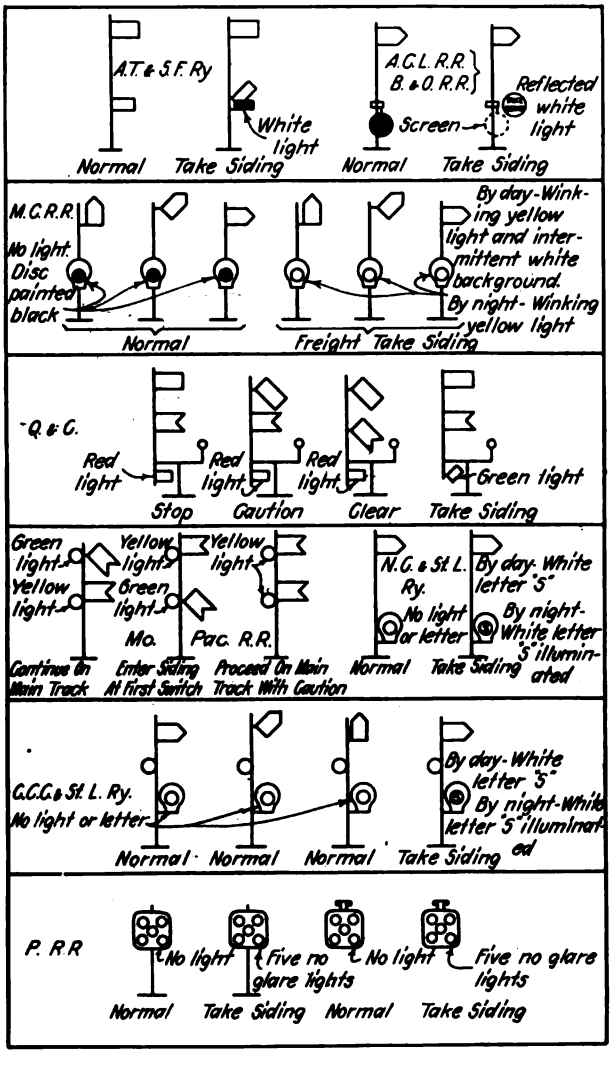
hidden behind a shield and lifted to the position to display the indication either mechanically or electrically, the disc being illuminated at night.

An R. S. A. committee reporting on this subject in 1918 presented the following fundamentals as governing the application of the take-siding indicator:

(a) The indicator should be distinct from other forms of signals. Take Siding Indicator.

(b) It should be located not less than braking distance from the switch in connection with whose approach it is to be used.



Take Siding Signal Indicators in Service on Various Railroads

(c) It should be in no way dependent on other signal control, either block or interlocking.

(d) It may be mounted either on a separate mast or on any other signal mast as meets properly the necessity for its use.

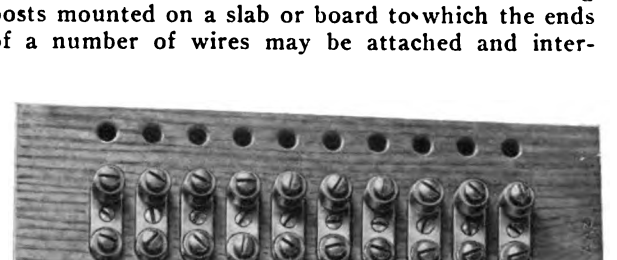
(e) Its day and night indications must be distinctive, avoiding possibility of confliction or of being mistaken for other signals.

(f) When not functioning, there is no necessity for its visibility, the value of the indicator being based on its distinct visibility at a distance of from 800 ft. to 1,500 ft. when displaying instructions for trains to take sidings.

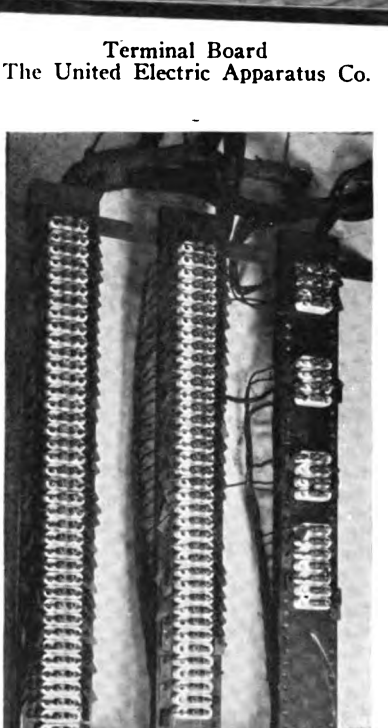
TAPPET. (1) A bar in an interlocking machine with vertical locking, operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them. (2) A pivot or swing dog in an interlocking machine with horizontal locking, attached to the locking bar and actuated or locked by the cross locking.

The tappet in vertical locking is connected by a tappet link to the rocker which is actuated by the lever of the machine and it actuates the front and back locking. Tappets vary in length from 1 ft. 5½ in. for use with a 4-space locking plate to 7 ft. 8½ in. for a 34-space locking plate. In the machines with horizontal locking the tappet (longitudinal locking bar) varies in length, depending on the layout of the locking. The bars are ½ in. by ¾-in. in cross section. See Locking.

TERMINAL BOARD. A collection of binding posts mounted on a slab or board to which the ends of a number of wires may be attached and inter-



Terminal Board
The United Electric Apparatus Co.



Terminal Board in Manhole, Showing Pot Head on End of Cable

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connected as desired by short pieces of wire or metal strips called jumpers.

Terminal boards are used in relay cases, power interlocking machines, towers, signal mechanism cases, manholes and similar locations where it is desirable or necessary to have a common terminating and distributing point for wires and cables coming into or going out of a location. Terminal boards also serve as convenient locations for making necessary electrical tests which may be required in clearing up cases of trouble that may develop on interlocking or block signal apparatus.

TIME INTERVAL SYSTEM. That system of train operation in which the distinctive feature is a time interval maintained at stations between trains moving in the same direction.

Trains are operated under this system by time tables, train orders and train dispatching. A minimum of five minutes is generally required between trains not carrying passengers and a ten-minute interval between trains carrying passengers. This interval is intended to allow a train delayed between stations time to send a flagman back to warn any following train. The time table is the primary authority for train movements, train orders supplementing the time table for movements not authorized by it or for the movement of regular time table trains on other than their regular time table schedules. Under this system trains are governed by train order and interlocking signals, neither of which is used to space trains.

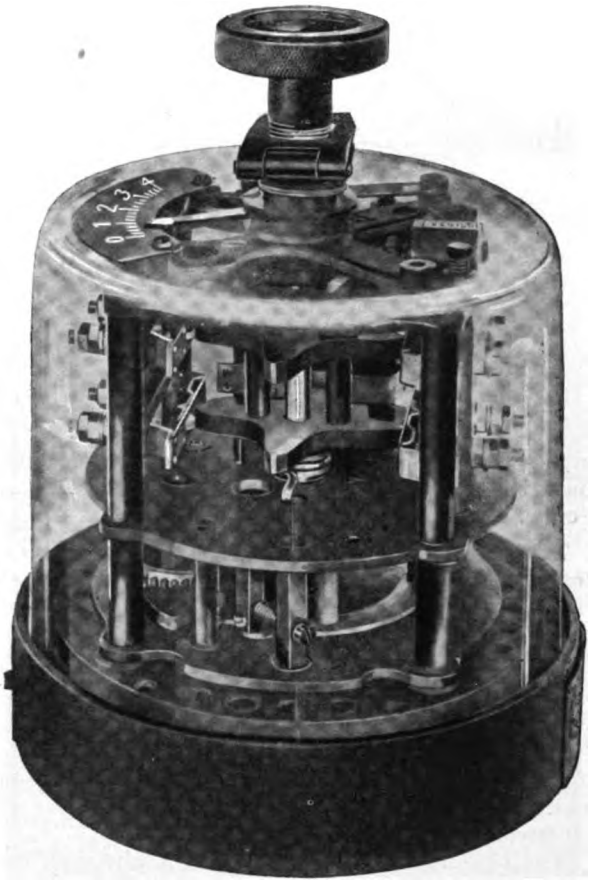
The I. C. C. in describing the limitations of this system, says that "without the block system, the right of a train to proceed depends (a) on the class of the train as regards other trains, (b) on the time as shown in the time table and (c) on the vigilance of the engineman in seeing that the preceding train is out of his way. With no block signal system rear collisions are provided against by flag or lantern signal, but the failure of this safeguard is notorious. It fails both from the negligence of flagmen to carry out or display the signal and of enginemen to heed it when given.

"On a single track line, in addition to these uncertainties, the men in charge of trains have the burden of considering these rights as against trains coming from the opposite direction, which are of two or more different classes, and the superiority of which, as related to their train, may vary from hour to hour, or may be varied by telegraphic orders from the train dispatcher at any stage of the train journey. Butting collisions, due to confusion in these things—to mistakes in reading the time table, to wrong telegraphic orders, to non-delivery of orders, to forgetting orders and other blunders—are as notorious as are rear collisions from flagmen's failures."

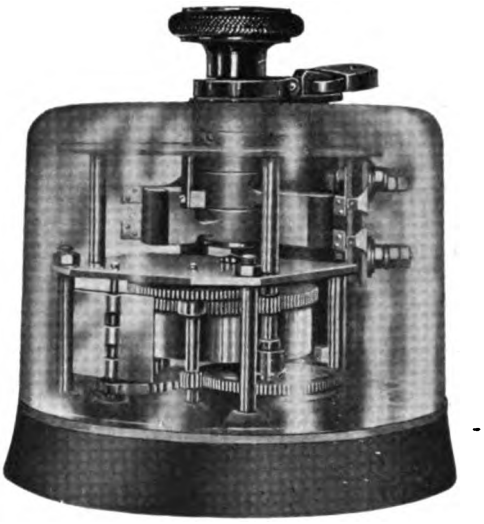
This system is employed mostly on branch lines and lines with light traffic. See Block Signal System, Automatic. Also Space Interval System.

TIME RELEASE, CLOCKWORK. A device, started manually, then working automatically, used for releasing an electric lock which, through error or because of being out of order or by reason of some other abnormal condition, holds a lever locked when it should be moved to avoid delaying a train.

This release is used in connection with electric locking at interlocking plants, etc., and consists of a spring-motor-actuated mechanism so arranged as to require from one to four or more minutes to operate after being started manually. The time interval may be varied to meet the conditions existing at any particular interlocking plant. In its operation it opens and closes contacts through which signal cir-



Clock Work Time Release
The General Railway Signal Co.



Clock Work Time Release
The Union Switch and Signal Co.

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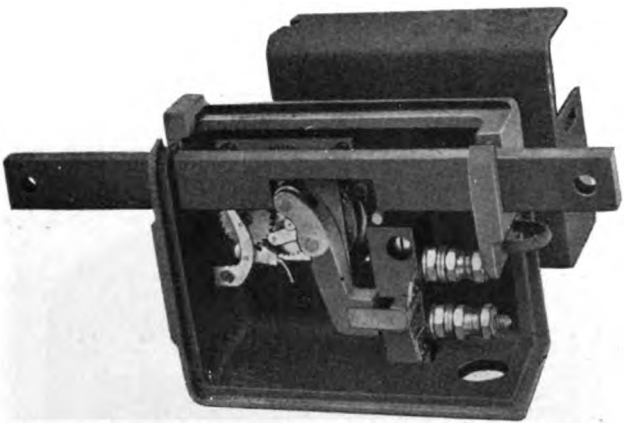
cuits are broken and is used at places where it is undesirable to use a manually-operated release which



Clock Work Time Release
The Federal Signal Co.

may interfere with the other duties of the leverman on a busy plant. See Release, Time. Also Release, Screw. Also Locking, Electric.

TO THE REAR OF A SIGNAL. The section of track back of a signal not governed by its indication, or that section of track occupied by a train before it has passed a protecting signal.

TOWER, SIGNAL. A building from which signals are operated, usually a two-story structure, the upper floor being the operating room, where the interlocking machine and levers and the necessary appurtenances for the operation of the various switch and signal units of an interlocking plant are situated.

The building is usually two stories, although that for housing machines of few levers at isolated locations is frequently of one-story cabin construction, while at other points due to special conditions a three-story tower may be employed, the operator's room being on the top floor, from which vantage point he is afforded the best view of the plant in all directions.

The types of buildings in common use are constructed of wood, concrete, brick, stucco or a combination of two or more of these materials, the selection depending upon local conditions, among which utility, economy and appearance are important. In large terminals or in high class suburban districts it is essential that the buildings have beauty combined with utility, as a neat appearance in such locations has a high advertising value, while on branch lines or at little frequented points a plain building will meet all reasonable requirements. The wood frame tower was the first type to be built and makes a satisfactory building for the average branch line at outlying points or where it may be necessary to build a new plant in a relatively few years. The main objection to this type of construction is the high rate of depreciation and the fire hazard, as a fire loss usually results in the destruction of the machine and appurtenances, with indirect operating expense for stopping all trains until a new tower is built and a machine installed. However, at a comparatively small plant it is possible, in case of fire, to operate the plant by hand for a few weeks or even months at a lower cost than the accumulated interest on the excess cost of an expensive building at such a location.

At the more important points and where changes are not likely to occur for a long time, towers of the more permanent fireproof construction are considered economical. It is hard to justify the construc-

Small Concrete Signal Tower

tion of expensive towers on the basis of economy for temporary or unimportant plants, and it is equally hard to justify a cheaply built wooden tower for permanent or important plants.

While concrete, brick and stucco towers are used there appears to be a tendency on the part of the railways towards the use of brick. In towers of fireproof construction concrete is generally favored for foundations and floors, while tile, slate and composition roofs are all in common use.

The lower story of the building is used for the leadout from the machine on the upper floor and for certain electrical appliances on a mechanical plant and, in many cases, as a tool room with a work bench and desk for the maintainer. Towers for power machines generally have the lower floor arranged for the housing of track and repeater relays, the storage battery, the motor-generator or gas driven generator set, terminal boards, power board, etc. Provisions are also made for the proper loca-

Large Concrete Tower for Interlocking Plant

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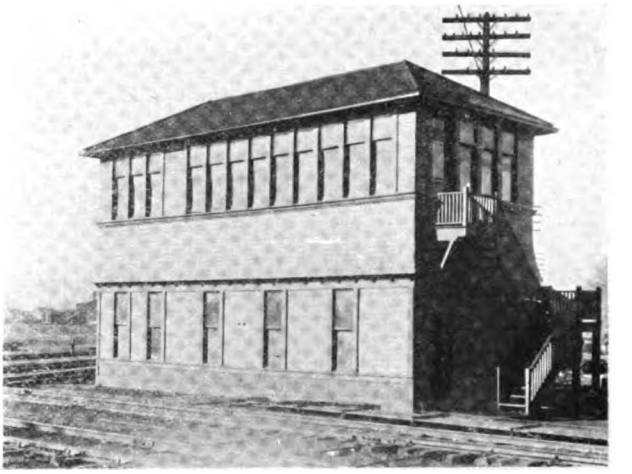
tion of the apparatus which requires that the floors be sufficiently rigid to support it properly.

As the view from the tower is an important feature, the windows of this room are designed and placed to afford the best view of the tracks, other windows being preferably omitted. While double-hung windows are the usual design, the single sash with only one pane of glass has the advantage of presenting a clear field of vision. If double-hung windows are used, care is taken to locate the meeting rails where they will not be in the operator's line of sight. In order to provide an air space to prevent window panes from frosting over in winter, tight storm windows are frequently provided, preferably with special devices for excluding the cold outside air effectually. Ventilation is commonly provided by means of transoms over the doors and sometimes through ducts in the chimney.

Unless the tower is heated, lighted or supplied with power from outside, the building must house the heating, generating and power plant, provided the installation requires all these features, which are usually located on the ground floor. The heating plant is preferably situated in the lower compartment with registers or radiators in the operator's room. Outlying towers are heated by stoves, a common type being a small way-car stove or similar heater placed inside a sheet iron drum or cone which extends from the level of the grate to the register in the floor of the room above to conserve the heat radiating from the surfaces of the stove. Steam heat is often supplied from a central plant outside the tower, hot air furnaces being seldom used.

Concrete floors are often provided in operating rooms, with a composition surface or a hard maple covering over the entire floor, while in other cases only a strip of rubber or cork is provided in front of the machine for the operator to stand on. The use of some such material not only adds to the comfort of the towermen but it tends to eliminate the fine dust that rises from the concrete and which settles upon the mechanical locking of the machine and causes excessive wear. It is also advisable to use a rubber mat on a hardwood floor.

In many cases but little attention has been paid to the location of telephone and telegraph apparatus



Frame Tower for Interlocking Having a Large Number of Mechanical Levers

in the tower and to the proper entrances for wires, with the result that the operating rooms present a poor appearance, and the operator must move from point to point to answer different calls. In the design of modern towers provision is being made by the two departments for the proper concentration of apparatus for the most efficient operation.

The size of the tower is generally determined by the extent of the interlocking; the minimum length of the building being determined by the length of

Reinforced Concrete Interlocking Tower on the Buffalo, Rochester & Pittsburgh

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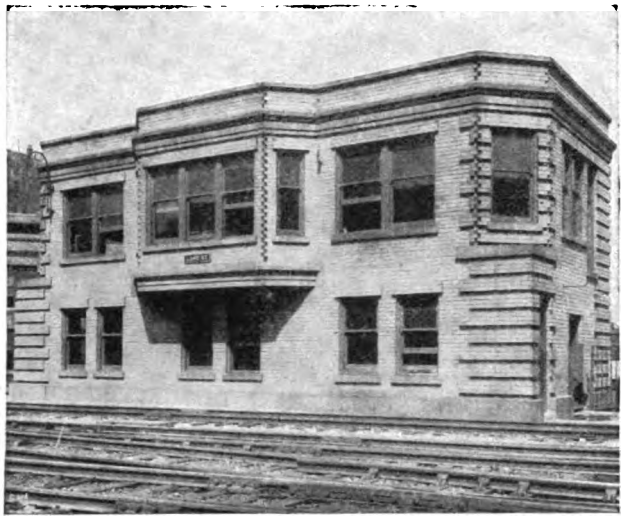
the interlocking machine. The width of the building, however, is generally greater than that required for the machine, as provision must be made for the table, lockers, etc., used by the operator and for the proper location of and access to electrical apparatus



Interlocking Tower of Brick Construction on the Chicago & Northwestern, Chicago Terminal

in the operating room, while in larger plants provision must also be made for a train director. The space required for the apparatus located on the lower floor also has a bearing on the size of the tower. The tower for a power interlocking may be smaller than one required for a mechanical machine of the same number of functions, as the power machine occupies less space. Towers range in size from 12 ft. by 12 ft. up, some common sizes being 16 ft. by 16 ft., 12 ft. by 26 ft., 16 ft. by 26 ft., 16 ft. by 22 ft., 16 ft. by 28 ft., etc., and in lengths up to 50 and 100 ft. for very large machines. A brick or concrete building should be of ample dimensions to accommodate possible extensions of the machine. One railway has adopted a standard tower large enough for a 40-lever machine, even where a much smaller

Interlocking Tower of Concrete Block Construction

machine is primarily installed. As wood frame towers can be enlarged cheaply it is very seldom necessary to build them larger than required for present needs. Proper provisions for the running of duct lines and conduit for power plants or for mechanical plants with electrical adjuncts should be incorporated in the design as well as arrangements for proper lighting.

Towers should never be placed closer than eight feet from the nearest running rail, while if there is likely to be another track built between the exist-

Typical Frame Tower at Interlocking Crossing in the Country

ing track and the tower the building should be located not closer than 23 ft. from the nearest running rail of the existing track. If a tower only requires windows on three sides, other conditions being equal, it should be located in a position where the blank side faces the north or the direction from which the prevailing storms come in winter.

TRACK CIRCUIT. A section of track, the rails of which are connected by bond wires to form part of an electric circuit, and insulated from other sections by insulated joints.

There are two general classes of track circuits, direct current and alternating current, which may be further subdivided between the normal closed or normal open type; and single or double rail circuits. Of the 60,992.3 miles of track on which automatic block signals are installed, 9,026 miles of track use alternating current for track circuits, while the other track mileage uses direct current for the track circuits.

The track circuit has made possible the present high development of modern block signaling. Its essential feature is the insulation of each section of track from the adjoining sections. Each rail in the section is connected to the one adjoining by bond wires, for the purpose of making a continuous conductor from one end of the section to the other, the contacts made by ordinary rail splices not being sufficiently dependable owing to wear, rust, and the loosening of the bolts. On electrically-operated roads where tracks are bonded for the return propulsion current with heavy copper bonds, no addi-

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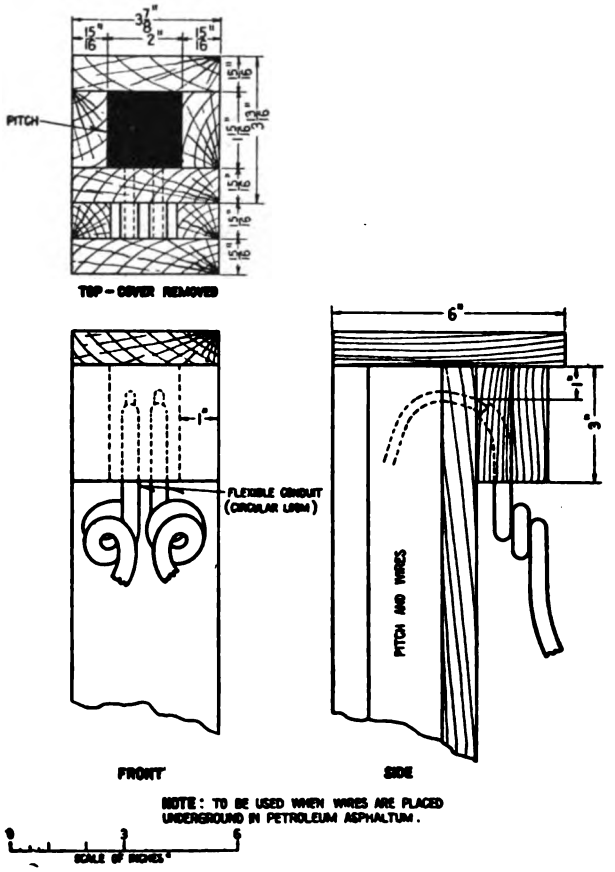
tional bond wires are necessary. The usual form of track circuit has a primary battery at one end of the insulated track section, with the positive terminal of the battery connected to one rail and the negative terminal to the other, while a relay at the other end of the section is connected to the rails in a similar manner. Current flows from the positive side of the battery through the one rail, the relay and the other rail back to the battery, thus keeping the relay energized.

The track relay is a development of the instrument of the same name used in telegraph service. It consists of an electro-magnet of the horseshoe type with a pivoted armature, carrying one or more fingers for making or breaking electric circuits for the control of signal apparatus.

The presence of a pair of wheels or train in the section will short circuit the battery, causing the



R. S. A. Bootleg Terminal for Track Connections

current to flow from the battery through one rail and the wheels of the train to the other rail and back to the battery, thus practically cutting off all current from the relay and causing its armature to drop. This result is obtained because the resistance through the wheels and axle of an ordinary car or engine is less than that of the relay. Consequently the wheels and axles deprive the relay of the current necessary to maintain its attractive power for the armature.

Track relays with resistances of 2 and 4 ohms are usually employed. In one case the train is assumed to be passing from the relay end to the battery end of the section and in the other case from the battery end to the relay end. The effect accomplished is the same except that the relay will not release so quickly when the train passes from the battery end towards the relay end, and this is in part due to the self-induction of the circuit through the relay coils, the rails and the axles of the train. It is due more, however, to small current leakage from the adjacent section and the effects of stray currents which are always present to a greater or less degree. A broken rail will also generally open the circuit and de-energize the relay.

Circuits for the control of the various signal devices are broken through the contact points of the track relay. Such apparatus cannot be operated directly by the track circuit because a battery of large electromotive force would be needed to furnish it with sufficient current. On account of the low insulation resistance of the ties and ballast it is unwise to use a battery of more than about two volts, for with any higher voltage the leakage from rail to rail, especially in wet weather, becomes equivalent to the presence of a train in the section. For the same reason track circuits cannot be made of unlimited lengths. The resistance of the rails also has to be considered in determining the length of a track circuit.

Cross ties have a relatively high resistance to the passage of electric current, but when a large number connect the rails many multiple paths are introduced into the circuit through which the current may flow from one rail to the other, and, considering them as a whole, the resistance they offer to the passage of the current reaches a relatively low value. Consequently there is always a current leakage from rail to rail through the cross ties and ballast. Every effort should be made to secure and maintain the best ballast and drainage possible on d. c. as well as a. c. track circuits. Cinders, dirty sand, soft waterlogged ties and ballast not well cleaned away from the base of the rail will produce track circuit trouble, particularly during wet weather, while good rock ballast, sound ties and clean track give the greatest efficiency.

Railroads hauling heavy refrigerator tonnage experience track circuit trouble because of the brine drippings from the cars impregnating the ballast and even new ties. The temperature has a marked effect on this action, as cold rain will not reduce the ballast resistance nearly as low as the same amount of precipitation will if the temperature is higher. Another bad effect of brine drippings is the forming of a coating of rust scale on the rail and angle bars, which because of its insulating properties forces practically all of the track current to flow through the bond wires instead of a considerable portion of it being carried through the angle bars, thereby materially increasing the total resistance. Practically all ballast is satisfactory and causes little or no track circuit trouble when it is dry or frozen.

The use of ties freshly treated with zinc chloride also reduces the ballast resistance. If too many such ties are used in a track circuit the current leakage between rails becomes so great that not enough current reaches the relay to hold it closed, the effect being the same as if a train is on the track circuit shunting out the relay.

A committee of the Railway Signal Association

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made the following recommendations in 1919 relative to the use of zinc treated ties in track circuit:

(1) As the electrical conductivity of the zinc-treated ties decreases with age during the first year better results may be had by allowing the ties to season for a period of from two to six months before using them in a circuited track, thus avoiding the use of the tie while its conductivity is greatest.

(2) For good results, the number of zinc-treated ties installed per year in any track circuit should not be greater than 15 per cent of the total number of ties in that circuit.

(3) (a) It is recommennded that a maximum rail resistance not to exceed 0.1 ohm per 1,000 ft. of track be maintained. Ordinarily it will be lower. This resistance can and should be reduced to a minimum by using bonding wires of high conductivity or increasing the number of bonding wires per joint.

(b) Rail and bonding resistance may be determined by the following formulae in which: E=Volts at rail—battery end; e=Volts at rail—relay end; I=Amperes flow from battery; i=Amperes flow through relay; R=Rail and bonding resistance total in ohms; r=Rail and bonding resistance per 1,000 ft. of track in ohms, and L=Length of track circuit in feet.

$$R = \frac{2(E-e)}{(I+i)} \qquad r = \frac{2000(E-e)}{L(I+i)}$$

(4) (a) The length of track circuit should be determined by the ballast resistance or the resistance from rail to rail through ties, ballast and track insulation.

(c) Ballast resistance may be determined by the following formulae in which: E=Volts at rail—battery end; e=Volts at rail—relay end; I=Amperes flow from battery; i=Amperes flow through relay; Y=Ballast resistance total in ohms; y=Ballast resistance per 1,000 ft. of track.

$$Y = \frac{2(E+e)}{(I-i)} \qquad y = \frac{2000(E+e)}{L(I-i)}$$

(d) Unless the ammeter with which the current readings are taken is of an extremely low resistance, such readings should be taken only for the purpose of determining the resistance of the unit and relay. The current flow should then be calculated from these resistances and the voltage drop across them, otherwise the error due to the resistance of the instrument will affect the results.

(e) When the rail resistance is equal to 0.1 ohm per 1,000 ft. of track a 2-ohm relay used, and the ballast resistance per 1,000 ft. of track as determined by the above formulae is as shown below, the track circuits should not exceed the lengths shown opposite the following resistances:

1-ohm —2,200 ft.	3-ohms—4,400 ft.
2-ohms—3,400 ft.	4-ohms—5,200 ft.

The lengths as above shown provide for the operation of the relay at 150 degrees F., under which condition, with 0.6 volts at the battery, 115 milamperes flows through the relay.

(5) Because of a low ballast resistance in track circuits where zinc-treated ties are used, a 2-ohm relay should be used, as it will operate satisfactorily when a relay of higher resistance will not.

For d. c. track circuits four types of cells have been used to a greater or less exent, the gravity cell; Lalande (soda) cell; storage cell; and dry cell. The gravity cell has a voltage of about 0.8 or 0.9 volts, the resistance varying with the manner in which the cell is maintained and averaging about 3 ohms. It will remain active for long periods on closed circuits without appreciable polarization. Because of this high internal resistance no external resistance is necessary to be connected between it and the rail of the track. The e. m. f. of the Lalande (soda) cell may vary from about 0.67 volt to 0.88 volt while the internal resistance will range between 0.019 ohm to 0.4 ohm. Because of the low internal resistance of these cells it is necessary to use on external resistance of the proper value between the cell and the rail. The storage cell is made in various capacities and a fully-charged cell on open circuits has a voltage of approximately 2.1 volts which, when placed on discharge, becomes approximately 2 volts and drops to about 1.8 volts when completely discharged. The voltage in this type of cell varies with the density of the electrolyte and to a certain extent with temperature. It has practically a negligible internal resistance and it is also necessary to use an external resistance in the leads between the cell and the track to prevent a flow of excessive current when a train occupies the track. The dry cell is used only in emergency cases or occasionally for open circuit track circuits of 2 or 3 rail lengths, which are used as annunciator starts to announce the approach of a train to a towerman. It is designed primarily for open circuit work and will polarize when current beyond a certain figure is drawn continuously from it. Dry cells are made in a number of sizes, the largest having about 75 ampere hour capacity and being capable of discharging about .250 ampere continuously without serious polarization. The ordinary size has about 25 a. h. capacity and a continuous current discharge of about .100 ampere. The dry cell has a voltage of approximately 1.3 to 1.6 volts, and its internal resistance varies from .1 ohm to .7 ohm.

The minimum working voltage of a battery is important, as a track relay must operate when the battery gets old as well as when it is new. Track circuits should be so adjusted that they will operate under the most adverse conditions. Approximately 0.6 volts should be the minimum working voltage. Where it is necessary to control signaling apparatus by track circuits over such a length of track that one circuit will not work, two or more circuits are employed. The controlled circuits may be broken through the relays of the successive track circuit or "cut sections" may be introduced.

The effects of temperature changes on track circuit operation are of considerable importance. The track relay is acted upon by temperature changes to a greater degree than any other part of the track circuit. For example, the 2 ohm relay at 70 deg. F. will measure 2.22 ohms at 122 deg. F. and 1.69 ohm at 0 deg. F. Similarly a 4 ohm relay at 70 deg. F. will measure 4.45 ohms at 120 deg. F. and 3.38 ohms at 0 deg. F. This effect can be checked up by the release values of the relay which is a very important matter, because when the temperature of the relay increases a correspondingly higher voltage is required to pick up the armature and likewise when the temperature decreases the armature will hold up with lower voltage across the coil. Consequently during cold weather a track relay is more liable to fail to release because of an imperfect train shunt than at any other time.

In drawing comparisons on the use of the 2 ohm and the 4 ohm relays the R. S. A. states that:

(1) Because of its lower operating voltage the 2-ohm relay will operate with a lower ballast resistance.

(2) The 2-ohm relay is less susceptible to leakage current from an adjacent battery entering the track circuit through insulated joints.

(3) Energy consumption for the 2-ohm relay on equal track circuits is approximately 50 per cent less when the track is occupied. When the track is not occupied the energy consumption will be less when the ballast resistance is less than 5 ohms per 1,000 ft.

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(4) The length of track circuit may be increased with the use of the 2-ohm relay if no foreign current is present and the resistance between the battery and the track is not less than the recommended limiting resistance.

(5) On track circuits of equal length the 2-ohm relay gives equally as good protection against broken rails where no foreign current is present.

(6) On track circuits of equal length, the 2-ohm relay will release with a higher shunting resistance across the rails when foreign current entering the track circuit is less than 0.350 amperes.

(7) Considering track circuits of equal length and other conditions equal, no definite recommendations can be made in favor of either the 2-ohm or the 4-ohm relay where foreign current is present on account of these being conditions where each has its advantages over the other.

(8) With foreign current present the 2-ohm relay on a track circuit of its maximum operable length will receive more combined foreign and track battery current than will be received by a 4-ohm relay on a track circuit of its maximum operable length.

(9) When a battery lead or a rail is broken and the track circuit between the break and the relay is shunted, the 2-ohm relay will be more susceptible to foreign current than the 4-ohm relay. With the track circuit not shunted, the 2-ohm relay will be more readily picked up by foreign current only when that current enters the track circuit through a resistance less than 5 ohms.

Normally open track circuits are also used to a limited extent, principally for annunciators. In these circuits the relay is normally de-energized as there is no connection between the rails. The presence of a train on the circuit picks up the armature, opening or closing the controlled circuit through its contact point. Current flows from the positive side of the battery to one rail through the wheels and axles of the train to the other rail through the relay and back to the battery. Here only one rail in each part of the circuit is insulated but this does not in any way affect the operation. In normally open track circuits the resistance of the relay should be lower than in normally closed circuits. Their use is limited necessarily to track sections of a few rail lengths; for in longer sections the low insulation resistance from rail to rail will allow the flow of enough current to hold up the relay after a train had passed out of the section. Gravity batteries should not be used unless the traffic is very heavy, as the gravity cells soon deteriorate and become inoperable on an open circuit. The use of normally open track circuits is also limited on account of the fact that there is no certainty that the relay will pick up. Any failure of the apparatus such as a broken rail, exhaustion or breakage of the battery cell or breakage at any of the wires will render the apparatus inoperative. Such failures are not readily detected as they merely maintain the apparatus in its normal condition, while with a normally closed circuit the reverse is true.

Single rail track circuits, so called from the fact that but one rail is insulated, are also used. Installations of this kind are made to avoid the expense of two insulated joints or where one rail is needed for another circuit. Such track circuits are more liable to failure than those having both rails insulated for the reason that the breakdown of one insulated joint will extend the circuit beyond the proper limit and cause interference of neighboring circuits or extended shunting of the relay, due to the presence of a train beyond the insulated joint.

A track circuit may be made to perform two separate functions in which the direction or polarity as well as the presence of current is made use of in the relay, provided the first or principal function actuated by the presence or absence of current does not interfere with the secondary function, actuated both by the presence of current and is polarity. For example, in a two-arm (home and distant) automatic signal, the home signal is controlled by its immediate track circuit, while the distant must be controlled by this circuit and the position of the next home signal in advance. In place of the ordinary track relay one of special design called a polarized relay is used. Such a relay is constructed like an ordinary track relay except for the addition of a polarized armature, which is caused to operate by a reversal of the direction of flow of current in the coils of the electro-magnet. Change of direction in the track circuit current is effected by a pole changer, which is actuated by any desired means such as a lever, signal arm, etc. The polarized armature also carries contacts for making and breaking signal circuits in a similar way to those operated by the neutral armature on the relay. It should be noted that in both cases the neutral or ordinary armature is attracted as in an ordinary track circuit. Polarized cut sections may also be used.

Where switches occur in a track circuit special means must be employed to prevent short-circuiting through the switch rods and leakage of current to the turn-out rail. The usual method is the use of insulated switch rods with insulated joints in the leads of the turnout and at the fouling point of the turnout. The switch points are bonded to the stock rails to insure shunting by a pair of wheels on any part of the track. For the same reason the upper main line rail is connected to the lower turnout rail by a jumper wire. This insures the shunt if a pair of wheels should be anywhere within the fouling point. It is desirable to have this jumper connected at a point midway between the insulated joint to insure the maximum amount of live track in case of a broken rail between the insulated joints in the lead and at the fouling point.

None of the methods employed in running track circuits through switches show any protection against an open switch. In order to obtain this protection a switch instrument or switch box is used. This consists of a device with electrical contacts, the whole mounted on a switch timber and connected to the switch point by means of a rod so arranged that when the switch slips open or is thrown open the movement of the rod actuates contacts which on being closed form a closed path from one rail to the other through wires connecting the rails to the contacts, thus when the contacts are closed by a switch being opened the same effect is produced as if a train was on the circuit shunting it out.

Some of the more common track circuit ailments are relay and track battery troubles, defective track connections, poor bonding and broken rails, short circuits or shunts, excessive leakage and defective insulated joints, all of which will cause the signals to be set in the danger position while defective relays, foreign current and poor wheel contact may result in a false clear signal indication with a train in the block section.

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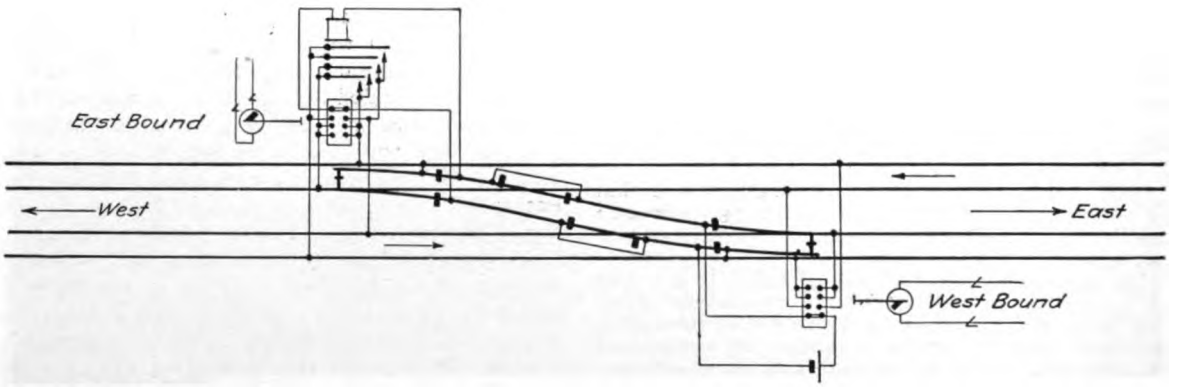
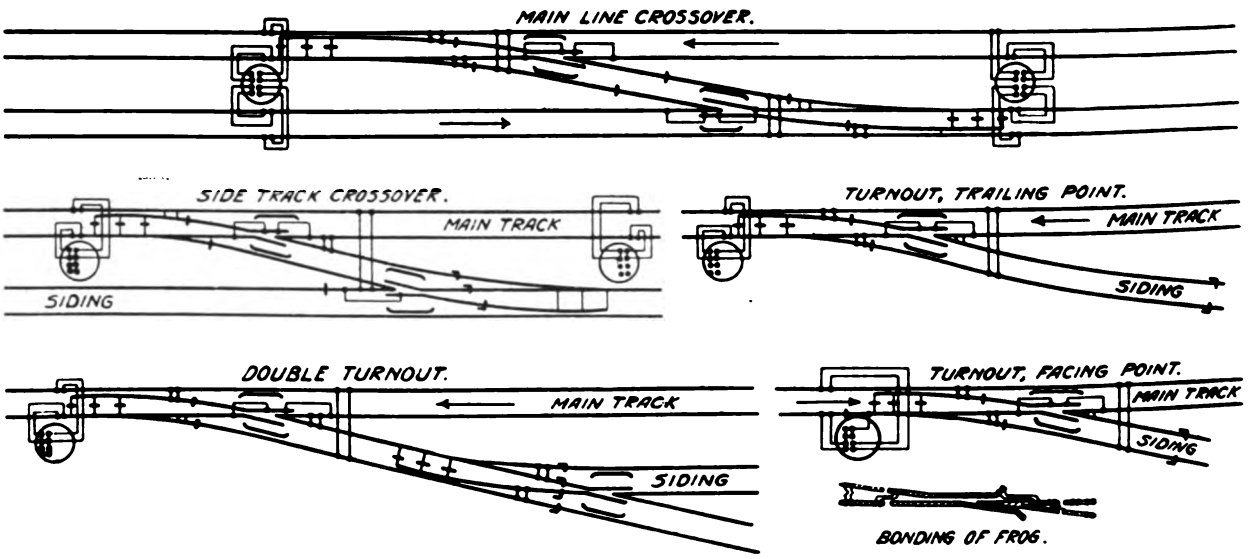


Layout Showing Separate Track Circuit for Crossover

Foreign Currents or Currents Foreign to the Track Circuits Which They Affect

Because of the danger of false clear signals being caused by foreign currents it is essential that steps be taken to combat it wherever it appears. These currents may get onto a track circuit by leakage through insulated joints from adjacent rails or may pass through the earth from a parallel track circuit or from direct current trolley rails in the vicinity; underground pipes, water mains, etc., are also possible sources of foreign current. To be dangerous these currents must set up a difference in potential between the rails of the track circuit and this may occur when one rail is better grounded than the other, while broken bond wires or broken rails may allow a train to occupy the section without releasing the relay. Foreign current troubles may usually be remedied by maintaining insulated joints in good shape and keeping ballast well cleared out under rails. Trolley companies operating near d. c. track circuits should be required to keep their rail return circuits well bonded as failure to do this may often permit a dangerous portion of their return current to flow through the track circuit rails. Where foreign current trouble cannot be eliminated in any other manner, alternating current track circuits should be used. Some of the best preventatives to guard against false clear signals from track circuits remaining energized with a train in the circuit are the use of as high a resistance as practicable between the battery and the track; the use of low resistance bond wires and the maintenance of bonding in good condition; keeping ballast well cleared away from contact with the rail and maintaining the insulation in insulated track joints in good condition at all times.

The importance of maintaining properly the insulated joints may be shown by means of the illustrations above. Referring to Fig. 1, assume the insulated joints have broken down at points 1 and 2 between track sections A and B so that part of the current can flow from the track battery from section B to the relay of section A. Assuming a train T is in section A, practically all of the current from track battery for section A will flow along one



Typical Wiring for Track Circuits at Turnouts, Crossovers and Frogs

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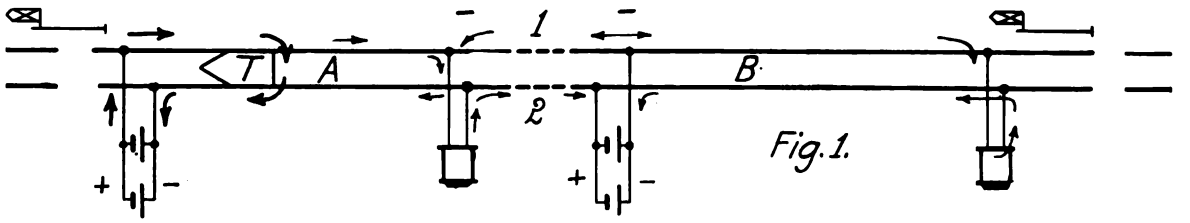
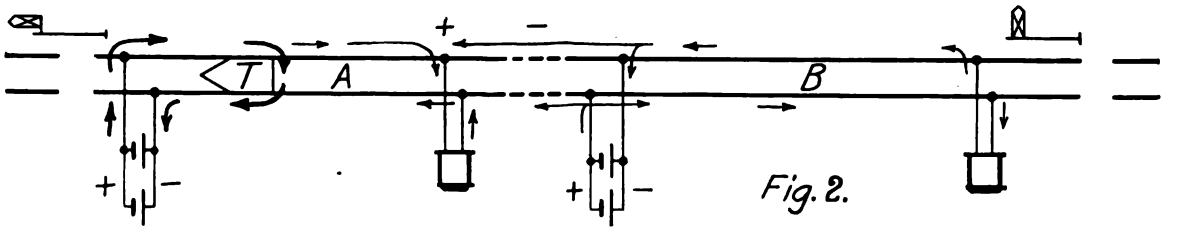
rail, through the wheels of the train to the other rail back to battery as indicated by the heavy arrows but the shunt cannot be so good that all current is entirely prevented from flowing to the relay, consequently a very small amount of current may reach the relay as shown by the light arrows. As the track battery for section B is located adjacent to the leads of the relay for section B, considerable current can flow from the battery B through the track relay and back to battery through the broken-down insulation of the track joints, the current from track battery B helping to augment the small amount which may be reaching track relay A while the train is on the circuit, as indicated by the arrows in Fig. 1. The train may be far enough away from the relay end of the circuit so that the rails and bonding between the train and the relay offer enough resistance that the train shunt will not prevent enough current from flowing from battery in section B through the relay for section A to allow the relay to open, in which case the signal behind train T may assume falsely a clear position with a train in the block as shown in Fig. 1. It will be noted in this



Why a Signal May Be Clear with a Train on the Circuit Because of Defective Insulated Joints

from the diagram that the current from the two directions with broken-down insulated joints will flow in opposite directions through the relay in section A. In this case the broken-down insulated joints (low resistance joints) would tend to decrease the current flowing from track section A. From the standpoint of operation, with no train on the track circuits, a track circuit is less liable to fail and cause a signal to assume the stop position when an insulated joint breaks down (offers but low resistance to the passage of the current from the rail in one track section to that in another) when the rails on each side of the joint are of the same polarity than when they are of opposite polarities, but with this **condition—there is greater danger of a signal remaining clear with a train in the block.** As far as safety is concerned, the better way is to arrange track circuits so as to have what is termed "staggered polarities" as indicated in Fig. 2. Under this method a higher degree of insulated joint maintenance must be maintained, otherwise signals will assume the danger position as explained above, **but there is less opportunity of a false clear signal failure occurring.**

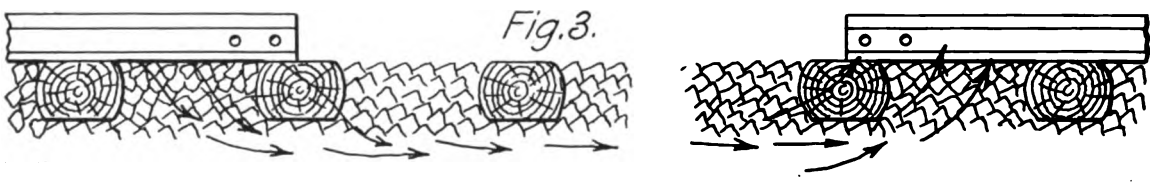


Sketch Illustrating the Arrangement of Track Circuits for Staggered Polarities

case that the top rail in the figure is connected to the same (or positive) side of the track batteries.

Referring to Fig. 2 it will be noted that the top rail in section A is connected to the positive side of track battery A while the bottom rail in track section B is connected to the positive side of track battery B so that the same rail in adjacent track sections will have opposite polarities. It can be seen

It may happen that when a rail is taken out of a track circuit or a broken rail occurs that the signal will not assume the stop position. This may be due to a by-path being provided for the current through a fouling circuit of a switch, broken-down insulation in switch rods, insulated joints or a path may be provided for the current from one rail through the ballast to the other rail when the ballast is up



The Leakage of Current Through Ballast With a Rail Removed May Sometimes Hold a Signal Clear.

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around the rails and on to the relay as indicated by the sketch in Fig. 3, the arrows indicating the path of the current. Once a relay is picked up or energized but a small amount of current is required to maintain it in that condition. This is one reason why it is important to keep the ballast clear of the rails and it is because of the conditions which may cause a relay to remain energized that rules are in force requiring the signalmen to disconnect a track relay when track forces are changing out rails. See Block Signal System, Automatic. Also Block System, Controlled Manual. Also Highway Crossing Protection. Also Relay. Also Cell. Also Bond Wire. Also Ammeter. Also Voltmeter. Also Polarization. Also Relay, Polarized. Also Rail Joint, Insulated (Track Section).

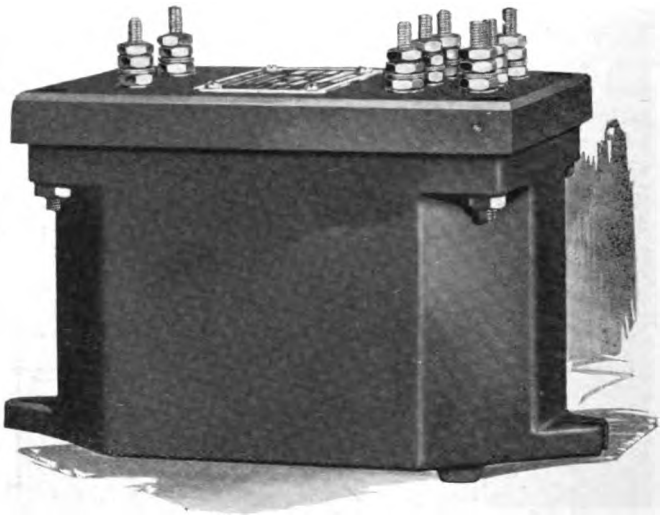
TRACK CIRCUIT, DETECTOR. A track circuit used in connection with electric detection, or section locking, and which is used to perform the same function as the detector bar. See Locking, Section.

TRACK CIRCUIT, HOME. That track circuit which governs the indication of the home signal, preventing it from being cleared while any part of a train is between the home signal and the advance block signal. This circuit is used generally in connection with the controlled manual block system where advance block signals are used at block stations. See Signal, Advance Block.

TRANSFORMER. A device for transforming an alternating current of high voltage into an alternating current of the same frequency, but of lower voltage, and of greater amperage or vice versa. A transformer which reduces the voltage is the step-down transformer; one which increases the voltage is the step-up transformer.

The usual form consists of two separate coils of wire wound on a soft iron core, the coil carrying the impressed current being the primary and the other the secondary. The action in the transformer is entirely inductive, the currents flowing in the primary coil inducing magnetic lines of force in the core, which in turn induce a current in the secondary coil. The voltage in the primary and secondary coils vary approximately with the number of turns of wire in each and the current inversely as the number of turns. Thus with 500 turns in the primary and 100 turns in the secondary, the reduction in voltage is 5 to 1 and the increase in current as 1 to 5. See Lines of Force. (See Page 695).

Oil-Cooled Line Transformer
The General Railway Signal Co.



Small Transformer with Terminals on Cover
The General Railway Signal Co.

U

UNIT (Operated). An operated unit is a switch, signal, lock or other device, which it is the function of a lever or other operating means to operate. (R. S. A.)

V

VARIABLE RESISTANCE. Resistance, the value of which can be readily varied or changed. An adjustable resistance. See Resistance Unit.

VOLT. The practical unit of measurement of electro-motive force. A volt is that unit which will cause a current of one ampere to flow through a circuit with a resistance of one ohm. See Ampere. Also Electromotive Force.

VOLTMETER. An instrument for measuring the electromotive force of a current of electricity in terms of volts. It is used extensively to determine the voltage of track circuits, batteries and signal circuits, the voltage at relays, signal slots, signal motors and similar apparatus.

The voltmeter, like the ammeter, is constructed in a number of different styles and types and may be classified in the same general groups as ammeters. Voltmeters are manufactured for use as portable

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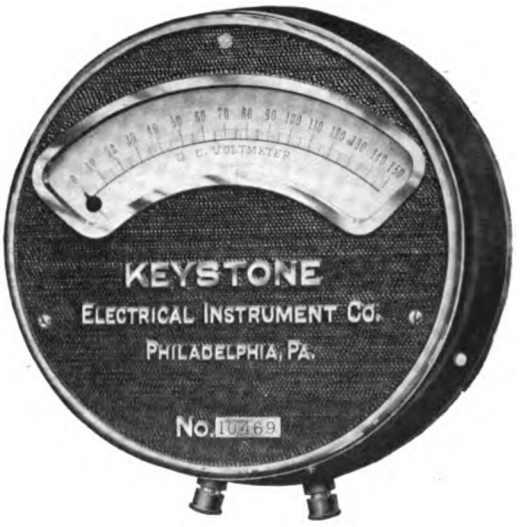
instruments, as switchboard instruments and for scientific or laboratory purposes. A portable instrument approximately 1.5 in. by 4.4 in. by 4.6 in. is used by signal supervisors, inspectors and others for testing purposes, while signal maintainers are usually furnished smaller, less accurate, but more rugged instruments of pocket size. In testing, a voltmeter is connected in multiple or parallel instead of in series with a circuit as is an ammeter, and, as this puts a shunt across the circuit, it is necessary that

Direct Current Voltmeter
The Weston Electrical Instrument Co.

Inspectors' Type Alternating Current Voltmeter
The Roller-Smith Co.

Triple Range Voltmeter
The Weston Electrical Instrument Co.

Maintainers' Type Alternating Current Voltmeter
The Roller-Smith Co.



Direct Current Keystone Switchboard Type Voltmeter
The Brown Instrument Co.

only a very small amount of current be allowed to flow through the voltmeter, otherwise too great an error will occur. For this reason a voltmeter has a high resistance, usually of several thousand ohms. The moving coil type is most commonly used on direct current circuits, while the electro-dynamometer and hot wire types may be used for either direct or alternating current circuits and are not affected by the frequency or the wave form of alternating currents. The induction type is suitable for use on alternating current circuits. The high resistance in a voltmeter is connected in series with the instrument and is contained in the case with it. External resistances known as multipliers are often provided so that the range of the instrument can be varied. See Ammeter.

W

WIRE (Electric Conductors). A slender rod or filament of metal of indefinite lengths. A wire is commonly circular in section and ranges in size from

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that which can be bent by the hand with some difficulty down to a fine thread. Wire is also made in square sections, flat like a tape, etc. Wire was originally made by hammering, a sort of a groove in the anvil serving to determine the size. It is now drawn by powerful machinery and passed through a series of holes which are constantly diminishing in size.

Although wire made of iron and copper is used to some extent as an electrical conductor in signal work, copper is employed almost universally. A copper wire with a steel center is also used extensively as line wire, while on some roads a No. 8 B. W. G. weatherproof iron wire is used for line control circuits in signal territory. The sizes of line wire more commonly used in telegraph work are No. 6, No. 8, and No. 9 B. W. G. galvanized iron, and No. 8 and No. 10 hard drawn B. & S. gage copper wire. The line wire used in signal work generally consists of No. 10 or No. 12 B. & S. gage hard drawn copper or copper clad wire and is generally insulated by means of a weatherproof insulation consisting of two closely-woven braids of cotton, each of which to be not less than 1/32 in. in thickness.

These braids are thoroughly saturated with a permanent weatherproofing compound which is applied in sufficient quantity to fill all interstices and form a continuous coating over the cover. Wires inside of buildings and those connecting instruments and lines to the rails of the track are of soft drawn copper, insulated with a rubber wall and covered with a braid and in some cases with tape and braid. These wires range in size from 00 B. & S. gage or larger down to No. 16 B. & S. gage.

The R. S. A. requires that the rubber insulation used shall be made of pure upriver fine dry Para rubber of the best quality and must be protected with a layer of closely woven cotton braiding at least 1/32 in. thick, saturated with a black insulating weatherproof compound that shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 203 deg. F. See Wire, Copper Clad. Also Wire, Signal.

WIRE, COMMON. A wire used jointly or "in common" by two or more electric circuits, through part of the route of each.

When two or more circuits are supplied with current from one source, as a battery, the main leads from the battery are common in such cases. In early practice it was customary to economize in the use of wire by making the ground a common return conductor for nearly all circuits in the same manner as is still done on certain telegraph and telephone circuits. Because of the difficulty in maintaining good ground connections, this practice has been discontinued to a large extent, the "common" wire being substituted. Although the use of the "common" wire is general at present, it has certain undesirable features, as its use results in complication of the circuits and occasionally trouble is caused by the common wire being overloaded, resulting in a drop in potential between different points. Again, if the common wire, for instance, at a power interlocking plant, becomes disconnected or broken, it is likely to interfere with the operation of the entire plant, and also under certain conditions is liable to cause it to operate improperly. Foreign currents also are sometimes collected or distributed by the common wire, especially where it extends several miles, as in automatic block signaling, and to limit the effects of such disturbing elements it is the present practice to limit the length of common wires to a few miles.

WIRE, COPPER CLAD. An electrical conductor made with a drawn steel center surrounded by copper. For lines strung on poles, by the use of copper and steel in the right proportions (copper for conductivity and steel for tensile strength) wire of a given conductivity can be made at a cost less than that for entire copper wire or steel wire. Good conductivity is obtained and a much greater mechanical strength results which is desirable where line wire is to be strung in climates where snow and other weather conditions make it hard to maintain line wires. Bond wires are also made of copper clad wire.

The R. S. A. specifications provide for a hard drawn bare copper-clad steel line wire having a certain per cent of the conductivity of that of pure copper. The wire shall be composed of a steel core with a copper coat concentrically placed around and permanently welded to it. The wire must be cylindrical in form, free from scales, flaws, inequalities, splits and all imperfections. Each coil must contain no welds, joints or splices.

The mechanical and electrical properties of the finished wire must be in accordance with the following requirements:

A. W. G.	Diameter in Mils	Minimum Breaking Strength in Pounds	Weight per M. Feet in Pounds	Maximum Resistance Ohms per Mile at 68 deg. Fahr.
6	162	1,800	72.0	7.96
7	144	1,450	58.0	10.08
8	128	1,200	45.5	12.74
9	114	975	35.5	16.04
10	102	800	29.0	20.04
12	81	512	18.0	31.78

The elastic limit shall be not less than 55,000 lb. per sq. in.; the elongation in 10 in. shall not be less than one per cent. The wire when broken by twisting, repeated bending, or when heated to a dull red and quenched in water at 32 deg. F. shall show no separation of the copper from the steel. Should the breaking weight of the coil be less than that specified, tests of two additional samples shall be made from the same coil and they shall determine the acceptance or rejection of the coil.

The wire shall be furnished in coils of not less than the following lengths: (1) Sizes 3 to 4, inclusive, ¼ mile; (2) sizes 6 to 8, inclusive, 1/3 mile: (3) sizes 9 to 12, inclusive, ½ mile.

The diameter of the eye of the coil shall be not less than 20 in. nor more than 22 in.

WIRE, SIGNAL. The wire, connecting a signal arm with its lever in the tower in connection with manually-operated semaphore signals.

The wire is usually of steel, of about No. 8 or No. 9 B. W. G. gage, and is supported on wire carriers fixed to short stakes set in the ground, or, if such are conveniently situated, on the heavier foundations used to support pipe connections. In either case the wire may be covered with trunking or boxing to protect against winter weather and pedestri-

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ans, if desired. It is a recognized practice on many roads in connection with "safety first" work to box in wire lines to prevent trainmen and others tripping over them. The wire by which a signal is pulled to the clear position is called the front wire, and that used to pull it into the stop position, the back wire. In Europe the back wire is generally omitted, as the counterweight close to the signal arm is depended on to pull the arm to the stop position when the front wire is slackened; this wire is also sometimes omitted in America. In case of breakage to the front wire, the counterweight is designed to pull the arms to the stop position. Where a signal wire line must be turned sharply to one side, a piece is cut out and a chain inserted in place of the wire, the chain running around the grooved wheel called the chain wheel. Because of the difficulty in keeping signal wires adjusted when they are lengthened or shortened by changes of temperature, rods (pipe) are now generally used, except for signals located quite a distance from the interlocking tower. For such signals the wire must be adjusted for temperature changes by wire adjusting screws in the tower. To avoid the difficulties connected with long distance signal connections, many roads use power-operated signal mechanisms to operate the distant signals, these being controlled by electrical connections from the tower.

The R. S. A. specification requires that this wire shall be cylindrical in form, free from scales, flaws, inequalities, splits, and imperfections. Each coil shall contain no weld, joint or splice. The wire shall vary not more than three mils from its normal diameter and shall weight not less than 370 lb. for No. 8 and 300 lb. per mi. for No. 9 B. W. G. The wire shall be "killed" or stretched one per cent before coiling and the coils shall be approximately 5 ft. in diameter and ½ mi. in length. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness, so applied that it adheres firmly to the wire and presents a smooth surface. The No. 8 B. W. G. wire shall have a diameter of 165 mils, a breaking strength of 2350 lb., with an 8 per cent elongation in 10 in., while the No. 9 B. W. G. wire shall have a diameter of 148 mils and a breakage strength of 1900 lb., with an 8 per cent elongation in 10 in. A sample of the wire, when gripped between two vises 6 in. apart and twisted, shall stand 10 complete twists in one direction without fracture. The specification further requires that a sufficient number of samples shall be taken from the wire, submitted for inspection and given a galvanizing test. See Wire (Electric Conductors).

WIRE RUN. An assemblage of wire lines in a common course with their carriers and foundations.

At power interlocking plants the wires used in connection with electric circuits on the plants run from a terminal board in the interlocking tower through trunking or conduits to the various functions which they govern.:

WIRE, SIZE OF. The sizes of wire are indicated by certain gage numbers of which there are a number of different ones in use. The B. W. G. (Birmingham Wire Gage) and the B. & S. (Brown & Sharpe) gages are the ones generally in use in the United States. The gages are listed in the form of a table. See Wire Gage. (General Section.)

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The
Wood Preservation Section

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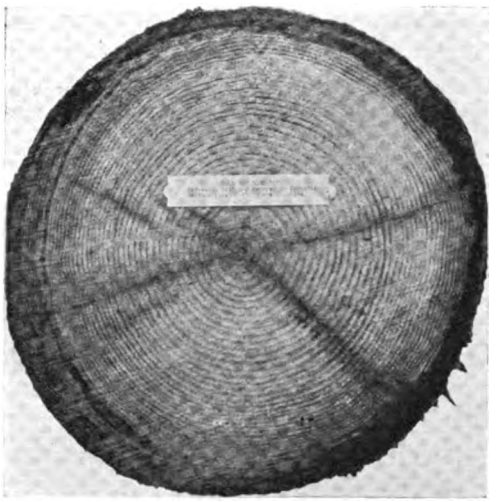
A

ANNUAL RING. A distinct concentric marking on the cross-section of timber, indicating annual growth of the tree.

The wood of the tree is made up of these concentric growths, one layer being added around the tree



End of a Log Showing Annual Rings

just under the bark each year. The spring growth is commonly more porous than the later summer wood and therefore has a different appearance, so that each annual ring is more or less distinctly double marked. See Wood.

B

BLEEDING. An exudation of preservative oil from the pores of a heavily treated timber when exposed to heat such as the sun's rays. See Wood Preservation.

BRUSH TREATMENT. The application of a preservative with a paint brush, the liquid usually being applied hot in two or more coats. (A. W. P. A.) See Wood Preservation.

BURNETTIZE. A term used to designate a zinc chloride treatment of timber, patented by Sir William Burnett. See Wood Preservation.

BUTT TREATMENT. A process of applying a preservative to the butts of timbers, usually in an open tank, where only one end of the timber is to be treated. This process is employed most frequently with materials such as cedar or chestnut posts, poles and piles which are to be driven or set with the large end in the ground. See Wood Preservation.

C

CASE HARDENING (TIMBER). The abnormal drying of the outer shell of a timber owing to rapid seasoning, tending to hold moisture in the interior of the stick which usually checks, cracks or splits internally as seasoning progresses. These internal cracks follow the medullary rays of the wood fibre and are called honey combing or hollow horning.

Case hardening tends to prevent the small checks that air drying produces when progressing moderately. This condition has been observed on ties, poles and piles which did not readily respond to treatment because the case hardened outer shell was impervious to preservatives.

CHELURA. A small crustacean resembling a flea which attacks wood much the same as limnoria, the galleries being about the same size, but running in all directions. Chelura were first called "sea fleas" or "red wood lice." They work in salt water and are much less common than limnoria. (A. W. P. A.)

COPPER SULPHATE. A salt, strongly poisonous to wood-destroying fungi and first used as a timber preservative in England.

CREOSOTE. An oil obtained by distillation from coal tar and used as a timber preservative, etc. In commercial usage the term is also applied to creosote oil in which some coal tar is dissolved.

Creosote oil has a specific gravity above 1.0, and boils between 200 and 400 deg. C. It consists principally of aromatic hydrocarbons and contains napthalene, anthracene, phenols, and bases in widely varying proportions. (A. W. P. A.) See Wood Preservation.

The A. R. E. A. has adopted the following specifications for Creosote Oil and for its use:

Specifications for Grade 1 Creosote Oil

The oil shall be distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.
2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38 deg. /15.5 deg. C. shall be not less than 1.03.
4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 deg. C. not more than 5 per cent.
Up to 235 deg. C. not more than 25 per cent.

5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall be not less than 1.03 at 38 deg. /15.5 deg. C.

The specific gravity of the fraction between 315 deg. C. and 355 deg. C. shall be not less than 1.10 at 38 deg. /15.5 deg. C.

6. The residue above 355 deg. C. if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.
7. The oil shall yield not more than 2 per cent coke residue.
8. The foregoing tests shall be made in accordance with the standard methods of the A. R. E. A.

In addition to the oil conforming to the above standard specification, the two grades specified below may be used when the higher grade oil cannot be procured:

Specifications for Grade 2 Creosote Oil

The oil shall be a distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.
2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38 deg. /15.5 deg. C. shall be not less than 1.03.
4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 deg. C. not more than 8 per cent.
Up to 235 deg. C. not more than 35 per cent.

5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall be not less than 1.03 at 38 deg. /15.5 deg. C.

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The specific gravity of the fraction between 315 deg. C. and 355 deg. C. shall be not less than 1.10 at 38 deg. /15.5 deg. C.

6. The residue above 355 deg. C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.

7. The oil shall yield not more than 2 per cent coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the A. R. E. A.

Specifications for Grade 3 Creosote Oil

The oil shall be a distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.

2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.

3. The specific gravity of the oil at 38 deg. /15.5 deg. C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 deg. C. not more than 10 per cent.

Up to 235 deg. C. not more than 40 per cent.

5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall be not less than 1.03 at 38 deg. /15.5 deg. C.

The specific gravity of the fraction between 315 deg. C. and 355 deg. C. shall be not less than 1.10 at 38 deg. /15.5 deg. C.

6. The residue above 355 deg. C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.

7. The oil shall yield not more than 2 per cent coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the A. R. E. A.

It is urged that when Grades 2 or 3 are used, consideration be given to the injection of a greater quantity of creosote oil per cu. ft.

Specifications for Creosote-Coal-Tar Solution

The oil shall be a coal-tar product, of which at least 80 per cent shall be a distillate of coal-gas or coke-oven tar, and the remainder shall be refined or filtered coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.

2. It shall contain not more than 2 per cent of matter insoluble in benzol.

3. The specific gravity of the oil at 38 deg. C. /15.5 deg. C. shall not be less than 1.05 nor more than 1.12.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 deg. C. not more than 5 per cent.

Up to 235 deg. C. not more than 25 per cent.

5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall not be less than 1.03 at 38 deg. /15.5 deg. C.

The specific gravity of the fraction between 315 deg. C. and 355 deg. C. shall be not less than 1.10 at 38 deg. /15.5 deg. C.

6. The residue above 355 deg. C., if it exceeds 26 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.

7. The oil shall yield not more than 6 per cent of coke residue.

8. The foregoing tests shall be made in accordance with the recommended methods of the A. R. E. A.

Precautions to Be Followed in the Purchase and Use of the Creosote-Coal-Tar Solution

1. The specifications for a creosote-coal-tar solution is submitted for the guidance of those desiring to use the coal tar addition to creosote.

2. There should be a distinct understanding between all concerned that a mixture is specified and used.

3. The refined coal-tar used shall be subject to inspection or analysis by the railway company at any time, such examination to be permitted upon request prior to the mixing of the solution.

4. In case the railway company makes its own solution of coal-tar and creosote, using crude tar for this purpose, it shall specify clearly as to the quality of the tar. Only low carbon coal-tar should be used, the amount of free carbon not to exceed 5 per cent.

5. The coal-tar may be added to the creosote at treating plants when suitable facilities for properly mixing the solutions are available, otherwise the solution should be mixed by the manufacturer, but subject to the inspection or supervision of the railway company. The coal-tar and creosote should be thoroughly mixed at a temperature of approximately 180 deg. F. before being applied to timber. The mixing should be done in tanks other than the regular working tanks, and the tanks containing the mixture should be heated and agitated thoroughly each time before any oil is transferred to the working tanks.

6. In treating with the mixture the temperature of the solution in the cylinder should not be less than 180 deg. F.

Methods of Accurately Determining the Absorption of Creosote Oil and Creosote Coal-Tar Solution

1. At railroad plants the absorption should be based on the treatment which will give the most complete penetration for each class or kind of timber, specifying complete penetration of the sapwood and as much of the heart as possible for the particular species or charge; payment to be based on the amount of oil used, plus operating and other charges.

2. Where railroads have their work done by contract, gallons should be specified for ties, posts, cross-arms and other material of uniform size, and pounds per cubic foot for other material; the same requirements as to sap and heart penetration to be applied as in the above.

Water in Creosote

Allowable Limits of Water.

1. The use of cresote in treatment containing up to 3 per cent water is permissible. Where the quantity exceeds 3 per cent, proper allowance should be made, but under no circumstances shall timbers be treated with oils having more than 6 per cent water.

Measurement of Oil.

2. In all cases where water separates from the oil in the tank or car, the water should be taken off to as great an extent as practicable and the oil measurement then should be made from the point of separation between the remaining water and oil as nearly as this can be determined. This refers to the physical process of measurement.

Sampling of Oil for Water Content.

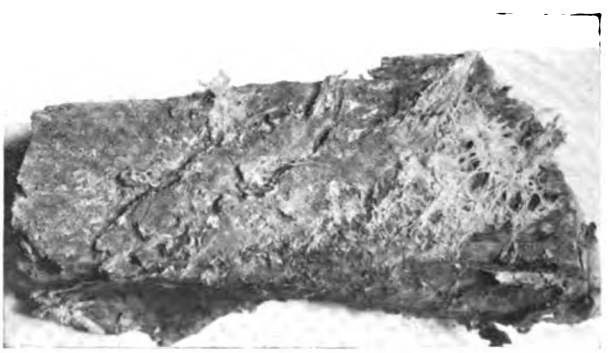
3. In sampling oil a drip sample should be used in taking samples from cylinders during treatment, and an approved cross-section tube should be used for taking samples from tanks or tank cars.

Storage Tanks.

4. All storage tanks should have a watertight roof.

D

DRY ROT. A term sometimes used erroneously to indicate a form of decay in timber occasioned by



Dry Rot of Wood

fungi as a result of which its substance is gradually reduced to a powder.

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E

EMPTY CELL TREATMENT. A treatment wherein the surplus preservative is removed, leaving the wood cell walls coated and the cells more or less empty. (A. W. P. A.)

The removal of the preservative usually is accomplished by means of a vacuum, drawn after the application of the preservative, or the initial air forced into the wood and held during the injection of the preservative, is depended on to bring out the surplus oil when the pressure is reduced to subnormal at the final stage.

The desirability of any empty cell process depends on the amount of preservative recovered after thorough impregnation, usually a minimum of 40 per cent of the oil injected. Empty cell processes are considered suitable for all classes of ties.

F

FULL CELL TREATMENT. Treatment to refusal, leaving the wood cells full of preservative. (A. W. P. A.) See Treatment, Empty Cell.

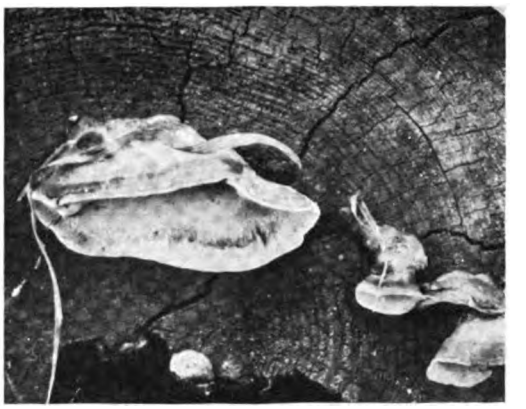
Injecting and leaving as much preservative in timber as it will retain is only justified economically in special circumstances as in the materials entering into permanent structures not subject to mechanical wear, and in wood piling and other timbers exposed to attacks of marine borers.

FUNGUS. A plant, some forms of which grow on or in and feed upon wood, destroying the latter by causing decay. (A. W. P A.)

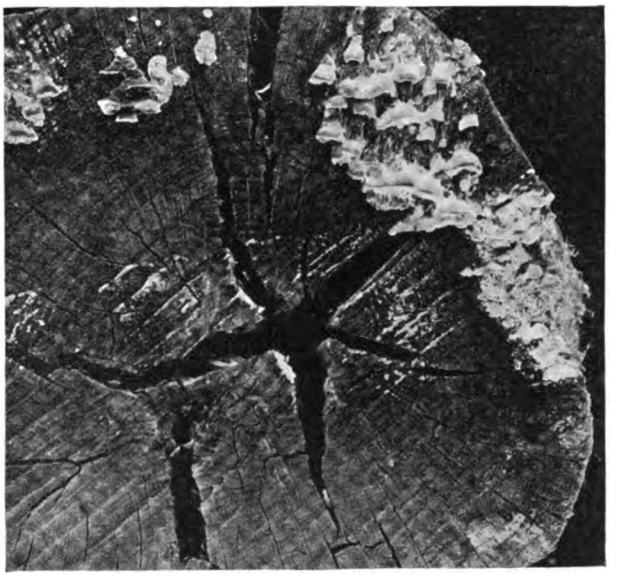
A Common Form of Fungus Which Attacks Oaks and Gums
From "The Decay of Ties in Storage" (A. W. P. A.)

Certain fungi are destructive of wood, while many more are quite harmless. The life of a wood-inhabiting fungus enbraces two stages of development, the vegetative and the fruiting stages. In the first, fine branching threads develop, penetrating the wood structure and sometimes appearing on the surface if the air is moist. The fruiting stage produces spores or seeds, sometimes on the exposed filaments as in molds, but more often on definite fruiting bodies which are really only compacted filaments, assuming forms characteristic of different species of fungi.

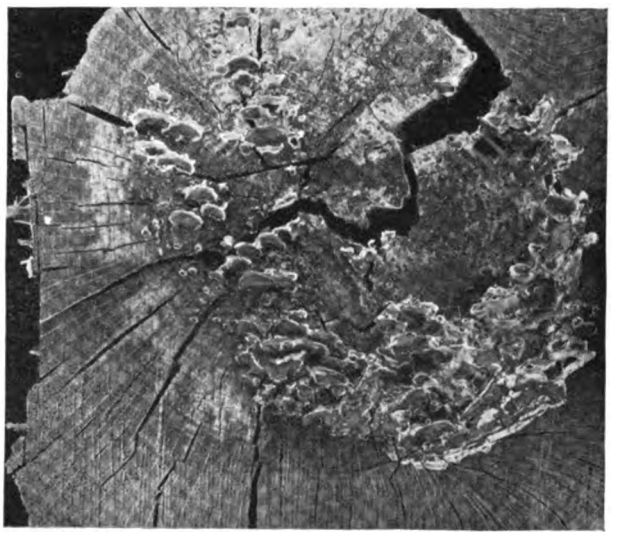
In the first or vegetative stage the filaments penetrate the wood as roots and absorb moisture. Molds or stains are fungi which are not destructive of wood as their roots rarely bore through the solid substance of the structure, entering only the ducts or pith rays. The main constituents of the wood



A Common Form of Fungus Which Attacks Coniferous Ties in the Northern and Western States
From "The Decay of Ties in Storage" (A. W. P. A.)



A Common Form of Fungus Which Attacks Hardwoods, Principally Oaks and Chestnuts
From "The Decay of Ties in Storage" (A. W. P. A.)



A Common Form of Fungus Which Attacks Hardwoods, such as Red Oaks
From "The Decay of Ties in Storage" (A. W. P. A.)

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substance are cellulose and ligno-cellulose (lignin), which when acted on by certain ferments, are changed into simpler substances readily assimilated as food by the fungus.

Propagation of the parasite, whether mold or wood-destroying fungus, is dependent on the formation of seeds or spores. The wood destroyers have distinct fruiting bodies, conspicuous and characteristic of their species in shape, color and texture. The spores or microscopic seeds, borne on or in the fruiting bodies, are white in many fungi but colored in others, appearing like fine dust, millions sometimes coming from one fruiting body, most of them capable of germinating new fungi under favorable conditions. Being extremely light they blow broadcast with every breath of air, their most active period being in moist weather when the best chance is afforded of settling on damp timber under circumstances favorable for infection. In addition to moisture the spore requires food, a suitable temperature and at least some small amount of air. The critical period, so far as moisture is concerned is that which precedes matured infection, when the newly located spore is putting forth filaments in search of food. Fungi differ in their moisture requirements, especially after becoming fairly established in the wood, although a moist atmosphere is in general favorable to all. Many will not develop on partially seasoned timber in storage, thriving only in the humidity of forests, but the majority resist drouth when established, some being dormant in dry weather but resuming growth during wet or humid periods.

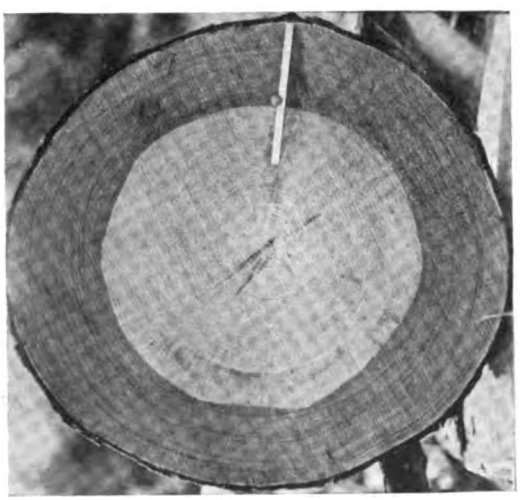
Air is necessary to the growth of fungi which can not live in saturated wood. The most favorable temperature range for this plant life is from 75 deg. to 90 deg. F., although they will grow more slowly in colder weather and are not killed, but remain inactive during the most severe winter seasons.

H

HEART TREATMENT. A treatment wherein all or most of the heartwood as well as the sapwood is penetrated by the preservative.

Heartwood of most species offers greater resistance to treatment than sapwood. See Heartwood.

HEARTWOOD. The older central part of a tree, usually darker than the sapwood. Growing an outer ring of wood each year, the inner rings are soon remote from the bark, and their cell walls, becoming thickened and crowded, give the heartwood a darker hue than that of the sapwood. See Wood.



End of a Yellow Pine Log Showing Sapwood and Heartwood

K

KILN DRIED. Artificially seasoned in dry kilns as wood, by means of hot air or steam, circulated through the piles. Thoroughly kiln-dried lumber contains about three per cent moisture, based on oven-dry weight of wood. Time required to kiln dry lumber depends upon the species of timber and size of pieces, varying from a few hours to several months. (A. W. P. A.) See Seasoning, Air.

KNOT. A hard mass of wood formed in the trunk of a tree by a branch, with the grain distinct and separate from the grain of the trunk. (A. W. P. A.)

While a knot is a recognized defect in any structural timber, it is not necessarily so serious as to cause rejection, small sized sound knots being permitted in the best grades. The crossing of grain due to the growth of the limb tends to cause separation in sawn lumber known as loose knots. See Knot. Sound.

KNOT, SOUND. A knot which is solid across its face, as hard as the wood surrounding it and so placed by growth or position that it will retain its place in the piece. A sound knot may be of any color and may contain checks and a pith hole not more than ¼ in. in diameter. (A. W. P A.) See Bridge, (Bridge Section).

KYANIZE. A term sometimes used in connection with the bichloride of mercury pressure treatment of wood, patented by John H. Kyan in 1832. See Wood Preservation.

L

LEACH. To dissolve out; used in the sense of loss of preservative from timber by the action of water. (A. W. P. A.) See Wood Preservation.

LIMNORIA. A small wood-boring crustacean with mouth parts arranged for gnawing or biting. The bodies are flattened and provided with numerous legs. Limnoria bore holes about $\frac{1}{32}$ in. to $\frac{1}{16}$ in. in diameter, and ½ in. deep, into the surface of the wood, leaving very thin partitions between adjoining galleries. These animals work in salt water, where they are common and destructive. (A. W. P. A.)

M

MARGARYIZE. A term sometimes used in connection with the copper sulphate treatment of wood patented by Margary in 1837. (A. W. P. A.)

MARINE BORER. An animal that attacks the wood structure of timber placed in salt water and sometimes in fresh water, usually boring into the wood at or near the surface and finally destroying the wood by riddling it with tubular galleries.

There are five principal wood-destroying borers, of which the teredo and limnoria are best known. Although these animals are most active in the salt

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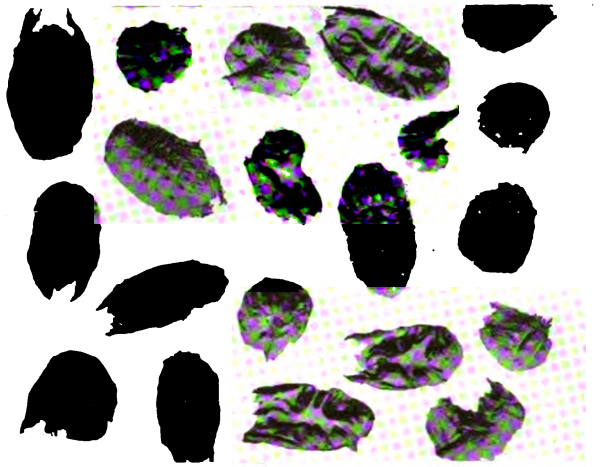
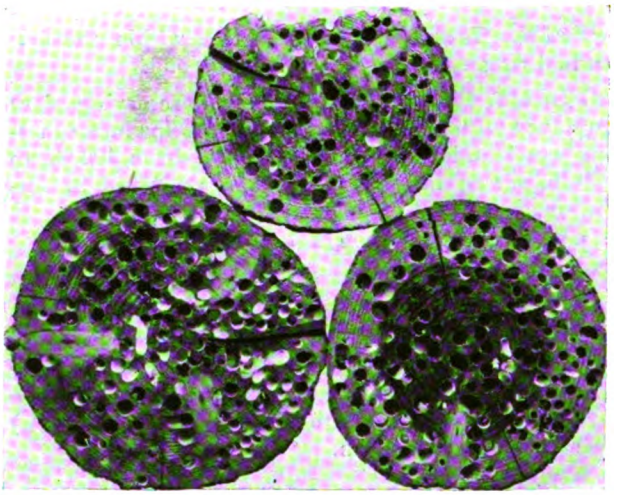
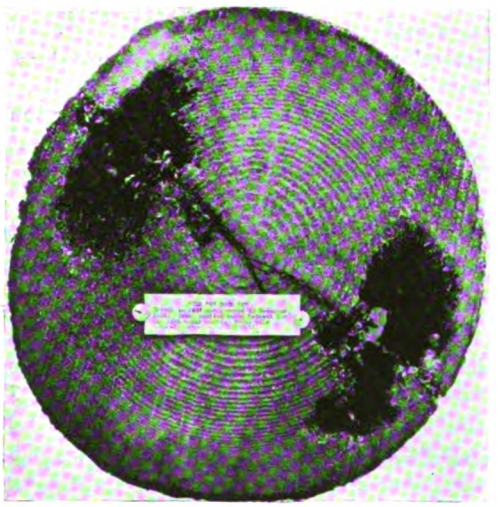
Teredo



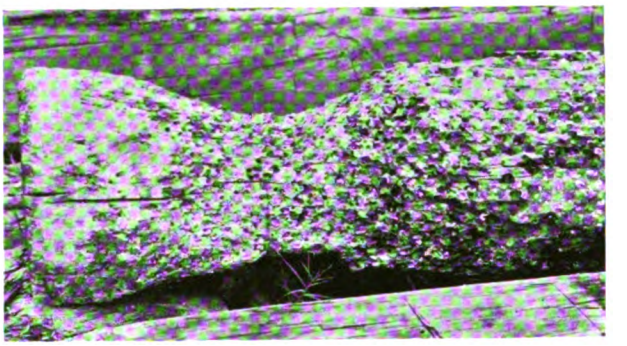
Sphaeroma



Ends of Piles Showing Effects of an Attack by Xylotrya



A Section of a Pile Showing the Effects of an Attack by Limnoria



A Pile Showing the Effects of an Attack by Teredo

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water of warm climates, they also sometimes infest northern waters, doing great damage to wood piles, etc. While piling is sometimes protected mechanically by means of sheet metal, concrete filled tiles, etc., the best method of resistance to marine borers is wood preservation, creosote being commonly and generally successfully used for the purpose.

O

OPEN-TANK PLANT. A wood preserving plant equipped with open tanks wherein timber is treated by submerging it in the preservative at atmospheric pressure. (A. W. P. A.)

P

PECKY. A term applied to a defect of the heartwood of cypress, consisting of pecks or holes, due to a fungus disease. (A. W. P. A.)

PENETRATION. The depth to which preservative enters wood, usually determined by boring with an increment borer or common auger. Test holes should always be refilled with a treated plug. (A. W. P. A.) See Wood Preservation.

PITH. The soft wood of a tree within the first annual ring. (A. W. P. A.) See Wood.

PLANT, PRESSURE. A wood preserving plant equipped with high-pressure cylinders for impregnating wood under pressure, usually at from 100 lb. to 200 lb. per sq. in. (A. W. P. A.) See Wood Preservation.

PUMP, MIXING. A rotary or other pump used for mixing preservatives for the chemical treatment of timber.

PUMP, PRESSURE. A hydraulic pump, usually of the duplex steam type, used for maintaining the pressure in the cylinder during treatment in order to force the preservative into the wood. (A. W. P. A.) See Wood Preservation.

PUMP, VACUUM. A pump for reducing atmospheric pressure, used in treating cylinders at wood preserving plants. (A. W. P. A.) See Wood Preservation.

R

REFUSAL TREATMENT. The treatment of timber continued under pressure until its absorption of the preservative ceases. The pressure is usually continued from ½ hour to 1 hour after the refusal point is reached when it is desired to give the timber the heaviest possible treatment. (A. W. P. A.)

S

SAP STAIN. The discoloration of sapwood caused by the attack of certain fungi which live upon the materials found in sapwood of newly sawn lumber. For southern pine, while this is considered a defect, it does not seriously impair the strength or durability of timber for treatment, and is not usually given much consideration. (A. W. P. A.)

SAP TREATMENT. The treatment of the sapwood of timber with little or no heartwood penetration. The heartwood of some species, such as white oak, beech, etc., is almost impervious to treatment. In such cases a thorough sapwood penetration is considered sufficient. (A. W. P. A.) See Wood Preservation.

SAPWOOD. The live part of a tree next to the bark through which sap flows, as distinguished from the darker and denser central column of heartwood. See Wood.

SEASONING, AIR. The drying of timber by exposing it under favorable circumstances to the circulation of air at atmospheric pressure to eliminate the moisture or a considerable percentage of it, usually with a view to future treatment with a chemical preservative.

To be air-seasoned the timber is placed in open piles out of doors where evaporation of the moisture may take place readily but without too great rapidity. Seasoning usually requires several months, depending on the condition and character of the wood and on the dryness of the climate. It is advisable to air-season most timber for eight months to a year to obtain the best results. Rapid seasoning tends to produce large injurious checks, the best practice being a gradual drying in a moderate climate. Air-seasoning is the usual preparatory process by which timber made receptive to the absorbtion of preservatives, being considered an important factor in the ultimate success of any chemical treatment. Although liquid may be forced into green timber by high pressure there is a marked tendency to thereby injure the wood structure; therefore the timber is preferably air-seasoned before pressure treatment.

As the seasoning depends on the weather it is advisable to locate the yard where the timber will be well exposed to the prevailing winds and distant from any body of water. Since seasoned timber will reabsorb moisture, the seasoning period should be that of least humidity and minimum rainfall. To obtain the best results the seasoning floor should be well drained and free from vegetation. The progress of seasoning is adjusted to the climatic conditions obtain a maximum of evaporation without undue warping and checking.

Hardwood track ties are seasoned not less than eight months and preferably twelve months. The wood is tested for moisture by the extraction and examination of borings, which should show not more than 30 per cent of moisture, or the wood is dried until it is of some predetermined dry weight.

SEASONING, OIL. The seasoning of timber by means of creosote oil with heat followed by pressure.

Partially green timber may be effectively treated by oil seasoning. Sufficient creosote oil is admitted to the cylinder to cover the timber, but not enough to fill the cylinder. The oil temperature is then gradually raised to about 200 deg. F. and held for 3 to 6 hours before applying pressure, (A. W. P. A.).

SPHAEROMA. A small crustacean quite similar to limnoria, but somewhat larger, being about ⅛ in. to ¼ in. long, and excavating a gallery ⅛ in to $\frac{3}{16}$ in. in diameter. The body is somewhat rounded instead of flattened, as in limnoria. It works in either fresh

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or salt water and is much less common than limnoria. (A. W. P. A.)

SPRINGWOOD. The inner part of the annual ring of a tree formed in the earlier part of the growing season.

STEAM VACUUM. A vacuum applied immediately after the steaming operation employed to reduce the moisture content of timber preliminary to the injection of the preservative. See Wood Preservation.

STEAMING, PRELIMINARY. Steam directly applied to green timber for artificial seasoning as a substitute for the longer process of air seasoning, before introducing a chemical preservative. See Wood Preservation.

SUMMERWOOD. The outer part of the annual ring of a tree formed late in the growing season. usually dense in structure. See Wood.

T

TAR ACID. An organic acid found in coal tar. Most tar acids are low boiling and soluble in water, and constitute the most antiseptic constituents of creosote. Coal-tar creosote contains usually about 5 per cent of tar acids, while water-gas tar contains no tar acids. (A. W. P. A.)

TAR, WATER-GAS. Tar obtained as a by-product in the manufacture of water-gas with steam, coke or coal and petroleum oil, used as a preservative material for timber.

TEREDO. A wood-destroying mollusk very similar to xylotrya and not readily distinguished from it. Its habits and effects on the wood are quite similar. (A. W. P. A.)

TREATMENT. The amount of preservative specified to be injected into timber, usually expressed in pounds per cubic foot. (A. W. P. A.) The treatment is economically limited to the amount which it is judged will preserve the timber from decay until it is worn out in service.

V

VACUUM, FINAL. A vacuum applied as the last step in a timber treating process, used to aid the removal of surplus preservative injected, and for drying the timber. (A. W. P. A.)

VACUUM, INITIAL. A vacuum sometimes applied as the first step in treating timber under pressure, to aid the penetration of the preservation injected and to dry the wood.

W

WOOD. The hard, fibrous substance which composes the body of a tree and its branches and which lies between the pith and the bark.

Wood is universally used in the manufactures and is considered so important that governmental forestry departments, composed of men specially trained in forestry are employed to devote their energies toward educating the public in the conservation of timber supplies, including reforestation, economy in the various uses of timber, prevention of the destruction of forests by fire, etc., and increasing the service life of sawed timber with chemical preservatives. The timber supply of America has been largely depleted, especially in the eastern portions which have been longest settled, to furnish materials for wooden buildings, fences, walks, paving, boxes, etc., and other materials than wood are now frequently substituted for many of these uses. The chief advantages of wood as a building material include the ease with which it can be cut to size, transported, resawed, worked with tools to any desired shape and finish, its strength, resiliency and comparatively light weight and specific gravity. Among its disadvantages are its inflammability, its short life on account of decay, especially when untreated, and the tendency to shrink and check or crack with loss of moisture. Wood however is so widely used and is so valuable that it continues as a vital factor of construction in many industries, where other materials cannot be substituted readily. With progress in results from conservation tending to minimize the destruction and increase the available supply of timber, this material will in all probability be available in perpetuity. The center of supply in the United States, which has moved gradually south and west from the New England and eastern states is now aproaching the forest of the northwestern mountain regions from which there may be expected increasing shipments of Douglas fir and other conifers for general use all over the country.

As to the character of wood the plant from which a tree grows, starts with either one or two first leaves at the top of the stem as it breaks through the ground from the seed. Plants having one first leaf produce endogenous trees which have a ring of hard fibres near the circumference while the inside is cellular as in the bamboo, whereas plants with two first leaves produce exogenous trees in which the hard wood is in the central portion and the larger celled wood is near the circumference. Such trees grow by adding each year a new ring of cellular tissue next to the bark, the central portion being known as heartwood and the outer portion as sapwood. All wood is composed of cells which vary in size, shape and arrangement in different species of trees but are quite similar in the trees of one species. Wood cells are like the cells of a honey comb but so small that they can only be seen distinctly under a microscope.

The circle of wood added beneath the bark of an exogenous tree each year is called an annual ring, slow growing trees adding narrow annual rings while fast growing timber is composed of wider rings. Where there are four distinct seasons in the year as in the United States, the cells forming the wood grown in the spring are larger than those formed later in the summer, this difference producing a notable contrast between the first wood of the new year and the last wood of the year before, resulting in a clearly cut boundary line for each annual growth, as may be plainly seen in the fibre of the end of a newly sawed log. The spring wood appears light colored and open pored as compared with the denser, harder late summer wood, although this distinction is much clearer in some species than in others. It is not clearly defined for instance, in the maple, the

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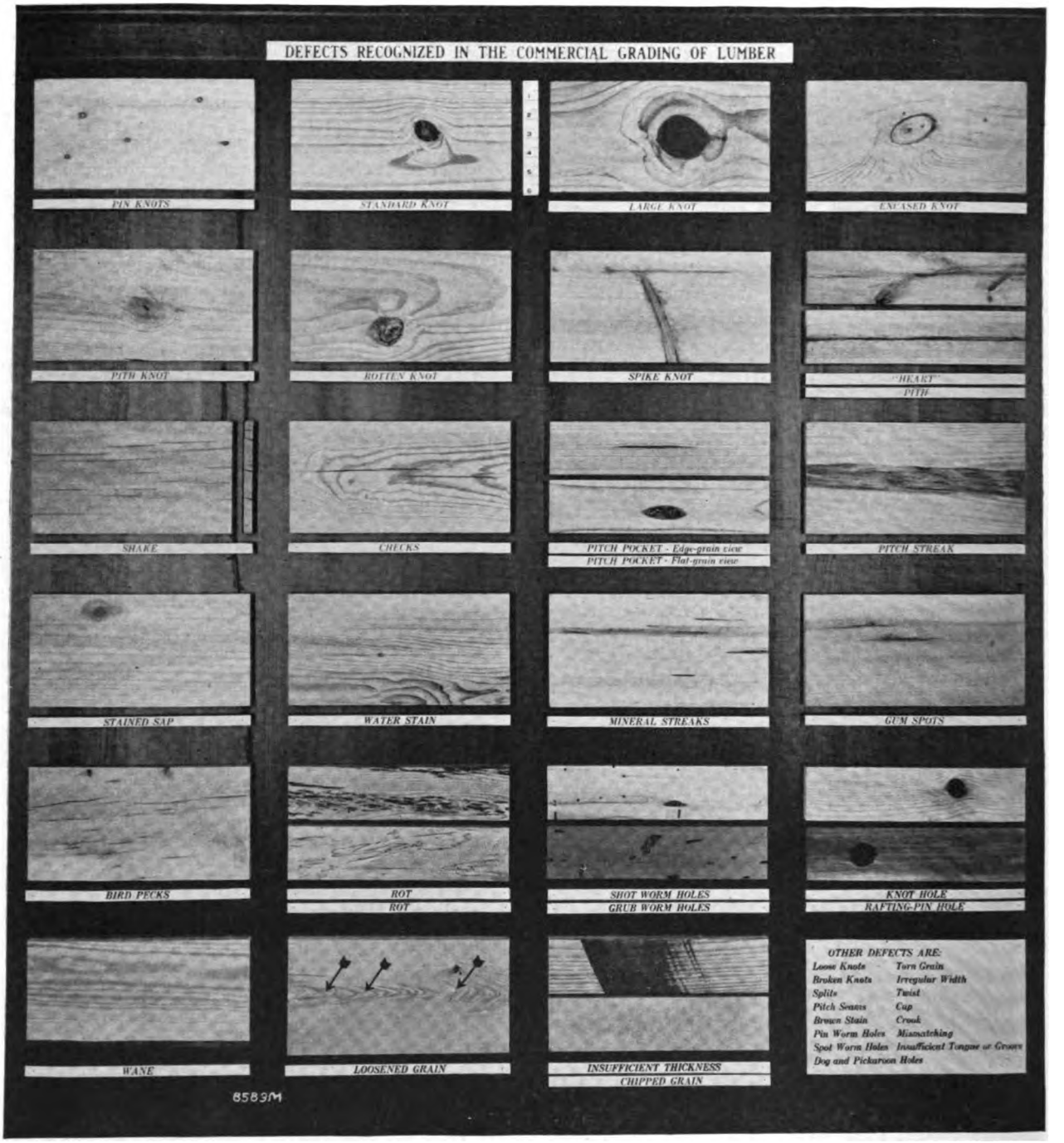
gum or the birch. The variations in the trees of one species result largely from local conditions such as climate, soil and the surrounding trees. Again a hardwood tree in a forest of tall pines will grow to a great height without attaining the girth or the large low branches which spread from isolated trees growing in open country. Exogenous trees spring wood, showing in cross-section as a distinct ring of holes, which in some woods is interrupted here and there by frothy ingrowths from adjacent cells, looking like crowded bubbles in a tube. Pith or medullary rays are narrow rows of cells extending radially from the bark inward toward the center of the tree, across the grain of the wood.



Defects Recognized in the Commercial Grading of Lumber, U. S. Forest Products Laboratory

are commonly classified as (1) hardwood or broad leaved and (2) softwood, or needle leaved conifers. Broad leaved trees have porous wood, the pores being composed of open end cells placed one on top of the other. These pores or longitudinal vessels are in each annual ring, being sometimes larger in the

Conifers have no woody fibres or pores, most of the wood being composed of long narrow cells arranged in definite radial rows, the cells in the darker summerwood being comparatively flattened and thick walled. The wood of pine, etc., has large longitudinal resin ducts and some smaller transverse ducts. If

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the freshly cut wood of a conifer is warmed, the resin will collect in specks on the ends, and brown lines of resin will also show along the grain of the split wood after exposure to the air, especially in pine. The pith rays in conifers are comparatively narrow and not always distinct.

All young wood is light colored but becomes darker with age, therefore the end of a log usually shows a ring of light sapwood around a darker inner circle of heartwood. Douglas fir and western larch sometimes have belts of light colored wood inside the heartwood, called internal sapwood. Young, healthy trees of all kinds have wider zones of sapwood than older trees, the sapwood varying in width from the butt of the tree upward, so that an annual ring may be in sapwood in one portion of a tree and in heartwood in another portion. The sapwood is much narrower in some species than in others. This feature together with the appearance of the bark and pith and familiarity with the taste, odor and color of the wood and its general texture and weight serve to help in identifying the species with the aid of a hand magnifying glass and a key to wood structure, although many kinds have striking characteristics which are unmistakable to the naked eye on casual inspection. Wood to be examined should be cut smoothly across the grain with a sharp knife.

KEY FOR THE IDENTIFICATION OF WOODS WITH THE AID OF A HAND LENS[1]

HARDWOODS.

I. Wood with pores. The pores are conspicuously larger than the surrounding cells, although in some species they are not visible without magnification. Neither the pores nor other cells are in continuous radial rows.

A. Ring-porous; that is, the pores at the beginning of each annual ring are comparatively large, forming a distinct porous ring, and decrease in size more or less abruptly toward the summerwood.

1. Summerwood figured with wavy or branched radial bands. The bands visible without a lens on a smoothly cut surface.

Many rays very broad and conspicuous. Wood heavy to very heavy. **The Oaks.**

(a) Pores in the summerwood very small and so numerous as to be exceedingly difficult to count under a lens; pores in the springwood usually densely plugged with tyloses. Heartwood brown without reddish tinge. **The White-Oak Group.**

(b) Pores in the summerwood larger, distinctly visible with (sometimes without) a hand lens and not so numerous but that they can readily be counted under a lens; pores in springwood mostly open, tyloses not abundant. Heartwood brown, with reddish tinge especially in vicinity of knots. **The Red-Oak Group.**

All rays very fine and inconspicuous. Color grayish brown. Wood moderately light. **Chestnut.**

2. Summerwood figured with long or short wavy tangential bands which include the pores. The bands visible without a lens on a smoothly cut end surface. Careful examination with a hand lens shows the pores of the summerwood to be joined in more or less continuous bands, and the bands to be evenly distributed throughout the summerwood.

(a) Sapwood moderate in width or narrow, mostly less than 3 inches; heartwood distinct, light to deep reddish brown. Rays not distinct without a lens. **The Elms.**

(aa) Large pores in the springwood usually in one row except in very wide rings.

(a3) Rows of pores in the springwood conspicuous because the pores are large enough to be plainly visible without a lens; they are mostly open, containing only a few tyloses; and they are fairly close together. Sapwood from 1 to 3 in. wide. Wood moderately heavy; fairly easy to cut. **White Elm.**

(b3) Rows of pores in the springwood inconspicuous because the pores are small, being barely visible without a lens; they are mostly closed with tyloses, especially in the heartwood; and they are often somewhat separated. Sapwood from ¾ in. to 1½ in. wide. Wood heavy and difficult to cut. **Cork Elm.**

(bb) Large pores in springwood in several rows; mostly open, containing few tyloses. Sapwood usually less than 1 in. wide, often only ½ in. wide. Wood moderately heavy. Inner bark mucilaginous when chewed. **Slippery Elm.**

(b) Sapwood wide, over 3 in., heartwood indistinct, yellowish or greenish gray. Pores in springwood mostly open, in several rows except in occasional narrow rings where they may form only one row. Rays distinct without a lens. Wood moderately heavy. **Hackberry. Sugarberry.**

BB. Careful examination with a hand lens shows the pores of the summerwood to be joined in more or less interrupted bands or in rounded groups of from 3 to 20 (especially in mulberry and coffeetree), the groups so arranged as to form tangential bands. In either case the bands are more pronounced in the outer portion of the summerwood than in the middle of the annual ring, where the pores are often isolated or in rounded groups.

(a) Large pores in the springwood containing numerous tyloses. Sapwood narrow, usually less than 1 in. wide.

(aa) Wood very heavy and exceedingly hard to cut across the grain. Rays not very distinct without a lens.

(a3) Heartwood golden brown with reddish brown streaks; coloring matter not readily soluble in cold water. **Osage Orange.**

(b3) Heartwood russet brown; coloring matter not readily soluble in cold water. **Black Locust.**

(bb) Wood heavy, but lighter than the above and fairly easy to cut across the grain. Color russet brown. Rays very distinct without a lens. **Red Mulberry.**

(cc) Wood moderately light and easy to cut across the grain. Color grayish brown. Rays not distinct without a lens. **Hardy Catalpa.**

(b) Large pores in the springwood open, containing no tyloses but occasionally a bright-red gum. Heartwood cherry-red to reddish brown. Wood very heavy.

(aa) Pores in the outer portion of the summerwood mostly joined into bands, the individual pores of which are not distinctly visible with a lens magnifying 15 diameters. Rays mostly very distinct. Pith small, usually under 0.15 in. Sapwood from ¾ in. to 2 in. wide on ties. **Honey Locust.**

(bb) Pores in the outer portion of the summerwood only occasionally joined into bands, the individual pores being distinctly visible with an ordinary hand lens. Rays of uniform width, inconspicuous. Pith large, usually over 0.2 in. Sapwood from ½ in. to 1 in. wide on ties. **Coffeetree.**

CC. Careful examination with a hand lens shows the pores of the summerwood to be isolated or in

[1] Unless it is otherwise directed, all observations as to structure should be made on the end surface of rings of average width cut smoothly with a very sharp knife; and all observations as to color should be made on a freshly cut longitudinal surface of the heartwood.

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radial rows of 2 or 3, but surrounded by parenchyma in such a manner as to appear in wavy tangential bands usually more distinct without a lens than with a lens.

(a) Parenchyma projecting tangentially from the pores in comparatively long lines often joining pores widely separated. Sapwood several inches wide; heartwood grayish brown, occasionally with reddish tinge. Wood heavy and hard. **White Ash. Green Ash.**

(b) Parenchyma not projecting tangentially from the pores or only slightly so. Sapwood less than 1 in. wide; heartwood silvery brown. Wood moderately heavy.

(aa) Rays fine but distinct without a lens; wood has a spicy odor and taste. **Sassafras.**

(bb) Rays not visible without a lens; wood does not have a spicy odor and taste. **Black Ash.**

3. Summerwood figured with numerous fine, light-colored tangential lines (parenchyma) which do not embrace the pores. Pores in the summerwood not much smaller than those in the springwood, usually visible without a lens. (Water hickory and persimmon are also classed as diffuse-porous woods.) Wood heavy to very heavy.

AA. Lines of parenchyma inconspicuous even under a lens. Rays in tiers, appearing on tangential surface as fine bands running across the grain. Heartwood black or brownish black. **Persimmon.**

BB. Lines of parenchyma conspicuous under a lens, barely visible without a lens. Rays on tangential surface not in tiers; heartwood reddish brown. **The Hickories.**

4. Summerwood not figured with radial or tangential bands. Pores in summerwood very small, not visible without a lens, isolated, or in radial rows of two or three. Sapwood very narrow, heartwood silvery or grayish brown. Wood moderately heavy. **Black Ash.**

B. Diffuse-porous; that is, the pores are of about uniform size and evenly distributed throughout the annual ring, or if they are slightly larger and more numerous in the springwood, they gradually decrease in size and number toward the outer edge of the ring.

1. Rays comparatively broad and conspicuous, the widest ones fully two times as wide as the largest pores, appearing on the radial surface as distinct "flakes" or "silver grain" similar to quartered oak, but finer. Color in various shades of light reddish brown.

AA. Practically all rays broad. Pores crowded, decreasing little, if any, in size at extreme outer edge of the annual ring. Wood usually lock-grained, moderately heavy. **Sycamore.**

BB. Only part of the rays broad, the others narrower than the largest pores. Pores crowded in the springwood, decreasing in size and number toward the outer edge of the annual ring, thereby giving rise to a harder and darker band of summerwood. Wood usually fairly straight-grained; heavy. **Beech.**

2. Rays narrower, but very distinct without a lens, the widest ones of about the same width as the largest pores.

AA. Color light brown with reddish tinge. Springwood and summerwood of uniform density. Sapwood wide.

(a) Wood heavy, difficult to cut across the grain. Only part of the rays broad, the others very fine, scarcely visible with a lens. Pith flecks rarely present. **Sugar Maple.**

(b) Wood moderately heavy, fairly easy to cut across the grain. Practically all the rays broad but not so broad as in sugar maple, therefore not so prominent but giving the appearance of being more numerous. Pith flecks common. **Silver Maple. Red Maple.**

BB. Color deep reddish brown. Springwood slightly more porous than summerwood. Sapwood narrow. Pith flecks common. Wood moderately heavy. **Black Cherry.**

3. Rays comparatively fine, narrower than the largest pores.

AA. Pores visible without a lens.

(a) Pores comparatively large and conspicuous without a lens, decreasing in size toward the outer limit of each annual ring; not crowded. Fine tangential lines of parenchyma often visible between the pores.

(aa) Sapwood wide, usually over 3 in. in ties. (Pores often in a more or less well-defined zone in the springwood, therefore also classed as ring-porous woods.)

(a3) Heartwood black or brownish black. Rays in tiers, appearing on the tangential surface as fine bands running across the grain. Wood very heavy. **Persimmon.**

(b3) Heartwood reddish brown. Rays not in tiers. Wood heavy. **Water Hickory.**

(bb) Sapwood narrow, mostly under 2 in. in ties; white or discolored; heartwood brown.

(a3) Wood heavy and hard. Heartwood chocolate brown. **Black Walnut.**

(b3) Wood moderately light and soft. Heartwood light chestnut brown. **Butternut.**

(b) Pores smaller, but on careful examination still clearly visible without a lens, at least in the springwood.

(aa) Pores not crowded, decreasing little, if any, in size toward the outer limit of the annual ring. Rays distinct under a lens. Heartwood pale to moderately deep reddish brown. Wood heavy.

(a3) Pith flecks rare. Inner bark has a wintergreen flavor. **Yellow Birch. Sweet Birch.**

(b3) Pith flecks abundant. Inner bark does not have a wintergreen flavor. **River Birch.**

(bb) Pores crowded, decreasing somewhat in size and number toward the outer limit of each annual ring. Rays very fine, barely visible with a lens. Pith flecks occasionally present but not abundant. Wood light and soft. Color white to light grayish brown. **Cottonwood.**

BB. Pores not visible without a lens.

(a) Pores appearing comparatively large and conspicuous under a lens.

(aa) Pores not crowded, decreasing little, if any, in size toward the outer limit of the annual ring. Rays distinct under a lens. Heartwood pale to moderately deep reddish brown. Wood heavy.

(a3) Pith flecks rare. Inner bark has a wintergreen flavor. **Yellow Birch. Sweet Birch.**

(b3) Pith flecks abundant. Inner bark does not have a wintergreen flavor. **River Birch.**

(bb) Pores crowded, decreasing somewhat in size and number toward the outer limit of each annual ring. Rays very fine, barely visible with a lens. Pith flecks occasionally present but not abundant. Wood light and soft. Color white to light grayish brown. **Cottonwood.**

(b) Pores appearing comparatively small under a lens.

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(aa) Heartwood pale reddish brown. Rays very distinct without a lens. Pores not very crowded. Wood moderately heavy. **Silver Maple. Red Maple.**

(bb) Heartwood dingy, reddish brown. Rays relatively not very distinct without a lens. Pores crowded. Wood moderately heavy. **Red Gum.**

(cc) Heartwood brownish gray. Rays not distinct without a lens. Wood moderately heavy.

(a3) Pores very small, only occasionally in radial rows of from 3 to 6. **Black Gum.**

(b3) Pores slightly larger, often in radial rows of from 3 to 6. (These distinctions between black gum and cotton gum can be applied only by comparison with a piece of wood known to be one species or the other.) **Cotton Gum (Tupelo).**

(dd) Heartwood yellowish brown with greenish tinge. Rays distinct without a lens. Wood moderately light. **Yellow Poplar.**

(ee) Heartwood creamy brown. Rays distinct without a lens; not in tiers. Wood light. **Basswood.**

(ff) Heartwood creamy white. Pores very minute. Rays very fine, barely distinct with a lens; arranged in tiers, producing very fine bands running across the tangential surface. Wood light. **Yellow Buckeye. Ohio Buckeye.**

CONIFERS

II. Wood without pores. The cells (tracheids) very small, barely visible with a lens; practically uniform in size, except in the summerwood, where they are narrower radially; and arranged in definite radial rows. Rays very fine.

A. Resin ducts present but often not distinct without a lens. (Exudations of resin over the end surface is a positive indication of the presence of resin ducts.)

1. Resin ducts numerous; scattered singly; conspicuous under a lens and usually visible without a lens as minute openings, or more often as darker or lighter colored specks, or as brownish lines on longitudinal surfaces. **The Pines.**

AA. Summerwood inconspicuous and not perceptibly harder than the springwood. **The Soft Pines.**

(a) Wood soft and moderately light; straight-grained. Annual rings of moderate width. Heartwood light reddish brown. **Western White Pine. Limber Pine.**

(b) Wood hard and moderately heavy to very heavy; often cross-grained. Annual rings narrow.

(aa) Heartwood reddish brown. Tangential surface has numerous slight depressions which give it a dimpled appearance, especially noticeable on split surfaces. **Bristle-Cone Pine.**

(bb) Heartwood creamy brown. Tangential surface not dimpled. Wood sometimes very heavy. **Pinon (Pine).**

BB. The summerwood conspicuously darker and harder than the springwood. (This feature is not so noticeable in the sapwood of old trees as in the heartwood, where the annual rings are wider.) **The Hard Pines.**

(a) Wood moderately light. **Western Species.**

(aa) The sapwood usually less than 2 in. wide (mostly about 1 in.). Tangential surface has numerous slight depressions which give it a dimpled appearance, especially noticeable on split surfaces. Resin ducts small, not visible without a lens. **Lodgepole Pine.**

(bb) The sapwood usually over 2½ in. wide (mostly over 3 in.). Tangential surface rarely dimpled. Resin ducts comparatively large, usually visible without a lens. **Western Yellow Pine.**

(b) Wood moderately heavy to very heavy. Heartwood orange-brown to reddish brown. **Eastern Species. Norway Pine. Pitch Pine. Shortleaf Pine. Loblolly Pine. Pond Pine. Longleaf Pine. Slash Pine.**

2. Resin ducts not numerous; scattered singly or in tangential groups of from 2 to 20; not visible without a lens, or appearing as whitish specks in the summerwood.

AA. The heartwood of the same color as the sapwood, or slightly darker, usually not clearly defined. Wood light. **Engelmann Spruce.**

BB. The heartwood decidedly darker than the sapwood. Wood moderately heavy.

(a) Heartwood orange-reddish to red. Sapwood over 1 in. wide. **Douglas Fir.**

(b) Heartwood russet brown. Sapwood usually less than 1 in. wide.

(aa) Annual rings narrow. **Western Larch.**

(bb) Annual rings moderately wide. **Tamarack.**

B. Resin ducts normally absent.

1. The heartwood of about the same color as the sapwood, distinction not clear.

AA. Wood has a spicy odor and taste; moderately light. Summerwood inconspicuous. Color pale brown. **Port Orford Cedar.**

BB. Wood does not have a spicy odor or taste, although other characteristic odor may be present.

(a) Wood whitish, at least in the springwood; the summerwood may be dark reddish brown, especially in pieces of rapid growth, and in that case forms a decided contrast between the springwood and summerwood.

(aa) Freshly cut surface of dry wood has a rank odor. Little contrast between springwood and summerwood. Rings of moderate width. Wood light. **Alpine Fir.**

(bb) Freshly cut surface of dry wood does not have a rank odor. Decided contrast between springwood and summerwood. Rings usually fairly wide. Wood moderately light.

(a3) Outer bark containing whitish layers. **White Fir.**

(b3) Outer bark containing thin, very dark reddish-brown layers. **Grand Fir.**

(b) Wood has a reddish hue, even the springwood has a pale reddish color; thus making the contrast between the springwood and summerwood less pronounced; odor somewhat sour in fresh wood. Wood moderately light to moderately heavy.

(aa) Wood coarse and splintery, often cup-shaken. Abnormal resin passages not present. **Eastern Hemlock.**

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(bb) Wood not very coarse or splintery usually not subject to cupshake. Abnormal resin passages occasionally present in tangential rows in the outer portion of the summerwood. **Western Hemlock.**

2. The heartwood distinctly darker than sapwood.

AA. Heartwood deep reddish brown. Annual rings regular in width and outline. Sapwood over 1 in. wide. Wood odorless and tasteless; moderately light. **Redwood.**

BB. Heartwood light brown to dingy brown with or without reddish tinge. Odor distinct when fresh surfaces are exposed.

(a) Odor somewhat rancid; heartwood tasteless. Annual rings mostly irregular in width and outline. Sapwood usually over 1 in. wide. Color highly variable from pale brown with or without reddish tinge to blackish brown. Weight variable from moderately light to heavy. Longitudinal surfaces feel and appear waxy. **Bald Cypress.**

(b) Odor aromatic (like cedar shingles); heartwood slightly bitter in taste. Annual rings narrow but regular in width. Sapwood rarely over 1 in. wide. Wood very light in weight. Longitudinal surfaces not appearing waxy.

(aa) Heartwood brown with reddish tinge. **Western Red Cedar.**

(bb) Heartwood brown, rarely with reddish tinge.

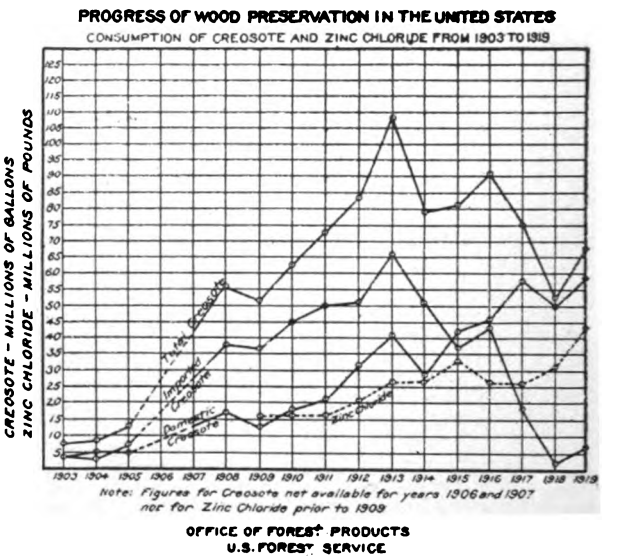
ARBORVITÆ (Northern White Cedar).
(See Page 815 and 816)

WOOD PRESERVATION. The injection into timber of chemicals poisonous to plant and animal life which are harmful to the structure of wood, with a view to preventing their attacks and thereby increasing the service life of the timber.

The chemical preservation of wood is of ancient origin, having been practised in the time of Pliny, while the Greeks and Romans charred wood or oiled it to prevent decay as did the early Britons and the Dutch, who used petroleum and linseed oil, coating or rubbing the wood with it. Animal, vegetable and mineral oils were all used as preservatives in early practice, as well as soluble glass, salt, etc. In Egypt also the preservation of wood and other substances by means of chemicals was reduced to a science and practised with great skill by the ancients.

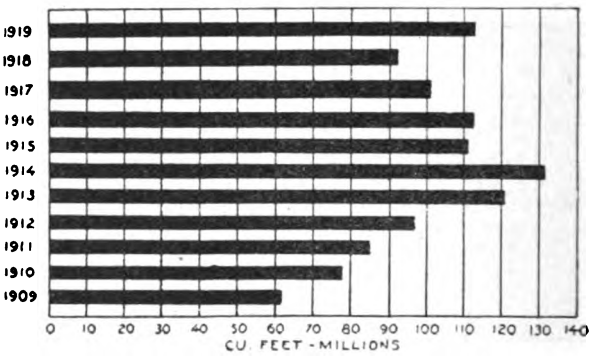
Railway ties were first treated in the United States in 1838 with bichloride of mercury for the Northern Central Railway in Maryland, now a part of the Pennsylvania system. The growth of the wood-preserving industry has since been rapid, especially in the railway field where it received an early impetus. In 1919 there were 108 active treating plants in the United States, of which 28 were owned by railway companies. These plants treated almost 140,000,000 cu. ft. of timber including more than 37,500,000 cross ties, 13,500,000 lin. ft. of piling, 144,750,000 ft. b. m. of construction timber, 121,500 cross arms and 8,250,000 ft. b. m. of miscellaneous lumber.

In general, railway cross ties represent about 8 per cent of the total of all timbers receiving treatment in the United States. The progress of timber preservation in the United States from 1903 to 1919 inclusive is comprehensively portrayed in the following chart of the U. S. Forest Service:



A Chart Showing the Progress of Wood Preservation in the United States from 1903 to 1919

The total of 140,000,000 cu. ft. of timber treated is subnormal, largely on account of the scarcity of preservatives. The preservative treatment of cross ties is shown in millions of cu. ft. from 1909 to 1919 inclusive, which indicates the revival of the industry since 1917 and 1918, the output in 1919 exceeding that of any other year since 1914 when the maximum of about 132 million cu. ft. was recorded.



A Chart Showing in Millions of Cubic Feet the Annual Totals of Cross Ties Treated in the United States from 1909 to 1919, Inclusive

Of the ties treated in 1919, 26,662,277 were hewed and 10,905,650 were sawed, while 4,914,379 ties were adzed and bored. The species of wood from which these treated ties were made, mentioned in order of greatest number, are southern yellow pine, 13,896,820; oak, 13,082,530; Douglas fir, 4,085,950, and western pine, 1,641,265.

The preservatives now chiefly used are creosote, zinc chloride and a combination of these chemicals, although mercuric chloride has long been recognized as valuable for this purpose and sodium fluoride has recently received marked attention. The preservatives used during 1919 include 65,500,000 gal. of creosote, 43,500,000 lb. of zinc chloride and 2,500,000 gal. of paving oil and miscellaneous preservatives.

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The changing conditions of the wood-preserving industry are shown in the chart in the gradual increase in the use of domestic creosote, the sharp decline in the amount of imported creosote consumed and the increase in the use of zinc chloride. The statistics of creosote consumption for the years 1906 and 1907 are not available, while 1909 is the first year for which the consumption of zinc chloride is known. The number of ties treated with zinc chloride in 1919 was 19,637,448, while creosote was used in 14,979,405 ties. Zinc and creosote combined were used in 2,950,074 ties.

The treating processes are classified as (1) non-pressure, and (2) pressure, the first providing a superficial coating by spraying, brushing and dipping, while the second is employed with a view to forcing the chemical into the fiber of the wood to impregnate the cellular structure of the interior. Non-pressure treatments include the older and simpler methods known as (1) the brush treatment, and (2) the open tank treatment. In the brush treatment the brushing or hot or cold preservatives into the timber is repeated two or three times, or the chemical may be sprayed on the timber.

In open tank processes, the timbers are immersed in a bath of hot or cold preservative liquid and then raised and allowed to drain so that the surplus liquid drips back into the tank. The timber may be immersed for any length of time or at any temperature with no loss of preservative other than by evaporation, which is about in ratio with the area of exposed surface and the volatility of the liquid. The length of the tank of course limits the length of timbers that can be immersed. Timber frequently is butt treated by standing the sticks upright in an open tank which is deep enough to immerse the large ends of the sticks to the desired height. An advantage of this method of treatment is that the tank need not be of great extent to impregnate the timber to a point which will be above the ground line when the post or pole is set in place, usually not more than 3 ft. for posts and 6 ft. for poles. The handling of preservatives in open tanks requires care to prevent undue loss on account of the dripping of liquid from the freshly treated timber, if it is not allowed to drain over the tank long enough after treatment.

Posts and poles, especially cedar poles, are butt treated in large numbers by the non-pressure processes, the butt ends being immersed in open tanks or painted or sprayed to a height which will be above the ground line when the pole is set in position. Frequently only a band is painted around the pole to include the ground line, where the timber has a tendency to decay. Timber bridge materials are sometimes similarly treated.

Pressure treating processes are of two distinct classes, (1) full cell treatments which force into and leave in the wood practically all the preservative it will hold where penetrated and (2) empty-cell treatments which aim to reduce materially the final retention of preservative while not reducing the depth of penetration.

The pressure system is most suitable where large quantities of timber require treatment and where deep and thorough impregnation is essential. The wood is placed in a horizontal metal cylinder where the preservative is injected into the wood by means of pressure. Wood preserving cylinders range in size from 6 ft. to 9 ft. in diameter and from 42 ft. to 172 ft. in length. A track is laid lengthwise through the cylinder and the timber to be treated is loaded on trams, which are then placed and remain in the cylinder with their loads during the process of treatment. The absorption of chemical per cu. ft. of timber varies from 2 lb. to 27 lb. of creosote, or from 0.4 to 0.6 lb. of zinc chloride. Treatments of 24 lb. of creosote or thereabouts, are given timber to resist marine borers, while 6 to 10 lb. are usually injected where ordinary decay is to be resisted, as in railway cross ties and bridge timbers. Creosote is adapted especially to the preservation of wood used in damp localities, whereas zinc chloride is better in dry places, where the rainfall is not sufficient to cause the preservative to leach out.

Piling which it is desired to protect from the ravages of marine borers, such as the limnoria and teredo, are heavily treated and frequently further protected by various methods such as encasing in concrete filled tiles.

Cross ties are treated by pressure, either with creosote or zinc chloride or a combination of these chemicals, with a view to preserving them to the extent of their service life, which is limited largely by mechanical wear. It has been demonstrated that under favorable conditions a tie in railway service may be preserved chemically and mechanically in track for 16 years or more, the conditions including well maintained track, good drainage, properly seated shoulder tie plates and heavy rail. The depletion of forests, resulting in scarcity and higher prices of ties, has brought preservative treatment into increasing favor, as the untreated tie will usually last less than seven years, its endurance depending largely on the climate, the kind of wood and the mechanical conditions.

Green timber as well as partly and thoroughly seasoned wood responds to pressure treatment. The moisture in green timber is often reduced in the cylinder by means of live steam and a subsequent vacuum before treatment, while a vacuum drawn at the end of the treatment expedites the draining of the surplus liquid from the cylinder and hastens the drying of the timber.

Of the pressure processes, those which are best known and most widely used in the United States are described below. (A. W. P. A.)

Pressure processes are classified as:

1. Full-cell treatments, which force into and leave in wood practically all the preservative it will hold where penetrated, thereby giving maximum protection against decay for that depth of penetration; and
2. Empty-cell treatments, which aim to reduce materially the final retention of preservative, while not reducing the depth of penetration.

Either green or seasoned timber can be treated by the pressure processes. When green timber is put into the cylinder it is often seasoned by means of live steam, followed by a vacuum to dry the wood before treatment. A vacuum is also drawn at the end of the treatment to hasten the draining of the surplus from the cylinder and to dry the timber.

The better-known pressure processes used in the United States are:

Bethell—(Full-Cell Process.)—Commonly used for the treatment of piles, poles, cross-arms, paving blocks, structural timbers, lumber and ties. Consists essentially of the following steps:

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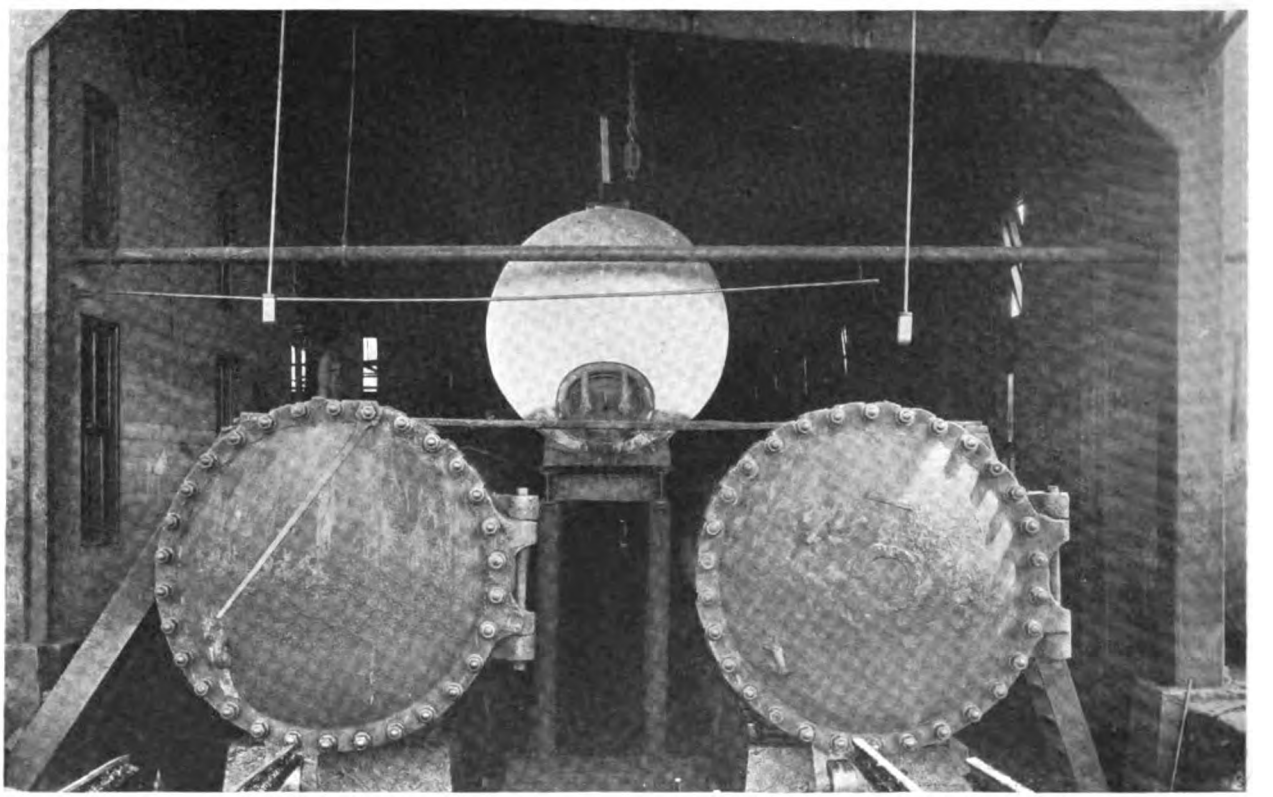
General View of a Timber Treating Plant



A Close-Up View of the Ends of Two Retorts in a Timber Treating Plant

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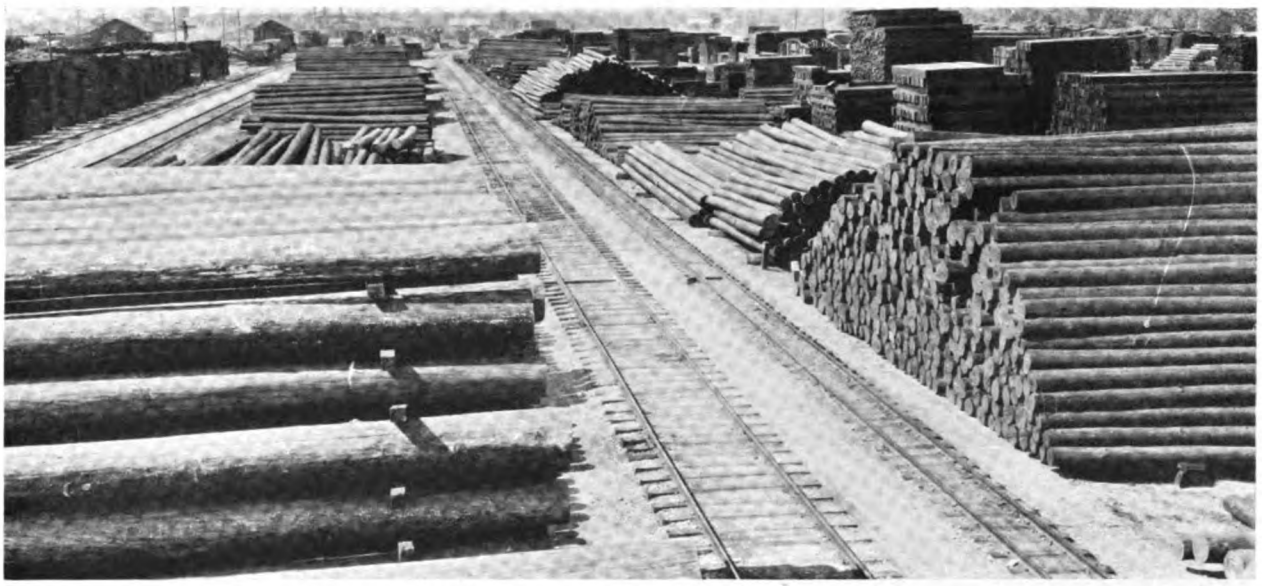
Ties Stored for Air Seasoning in a Timber Treating Yard



Posts, Poles, Ties, etc., Piled in the Yard of a Timber Preservation Plant

a. Preliminary vacuum one-half to one or more hours.

b. Oil injected under pressure, the maximum usually being between 100 lb. and 180 lb. per sq. in.

c. Final vacuum (sometimes omitted).

Green timber is usually subjected to a live steam bath at about 20 lb. pressure for several hours before the preliminary vacuum. Seasoned timber is not usually steamed in this process, except in the case of paving blocks. The amount of oil injected depends upon the specifications of the purchaser, but the absorption per cu. ft. is usually within the following ranges:

Lumber, poles, structural timbers, cross-arms, ties, fresh-water and land piles, 8 lb. to 12 lb.

Paving blocks, 12 lb. to 20 lb.

Salt water piles, 16 lb. to 24 lb.

Boiling. Used chiefly for creosoting Douglas fir piles, timber, lumber, ties and paving blocks. Consists essentially of the following steps:

a. Wood (either green or seasoned) in the retort is covered with oil at about 160 deg. F.

b. The oil is heated to 225 deg. to 250 deg. F. at atmospheric pressure and the vapors are passed through a condenser.

c. Heating is continued until the rate of condensation falls to 1/6 lb. to 1/10 lb. of water per cu. ft. of wood per hour. This frequently requires 40 to 60 hours for green timber, and sometimes more.

d. The cylinder is filled with cool oil, allowing the temperature to fall.

e. Pressure is applied, the maximum being 120 lb. to 150 lb. per sq. in., until the desired absorption is obtained; usually 10 lb. to 12 lb. per cu. ft.

Boulton. (Boiling Under Vacuum.) Used chiefly for the treatment of Douglas fir piles, timber, ties, lumber and paving blocks. Consists essentially of the following steps:

a. The timber is immersed in hot creosote and subjected to a vacuum, and the escaping vapors drawn through a condenser.

b. Temperature (usually 190 deg. F. to 210 deg. F.) and the vacuum is maintained until the rate of conden-

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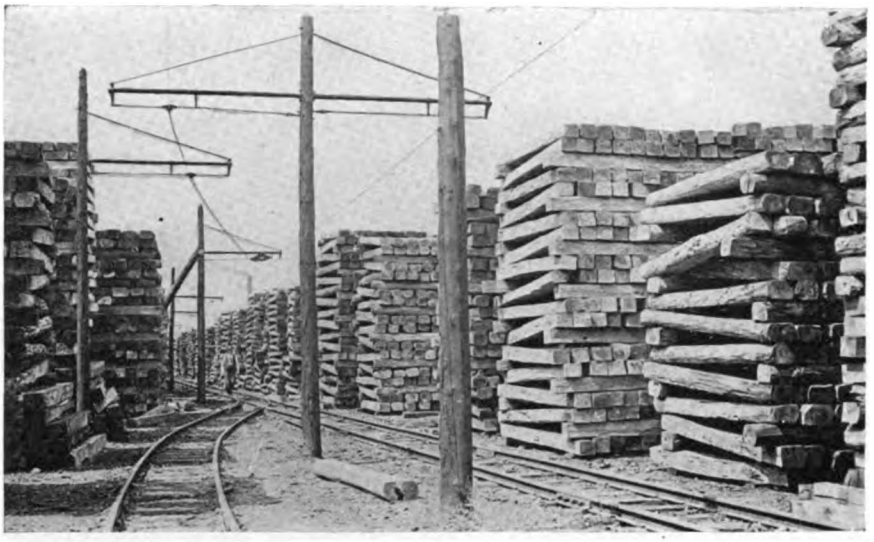
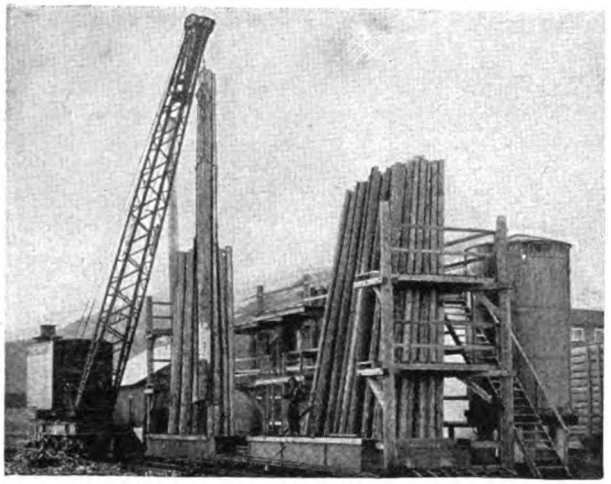
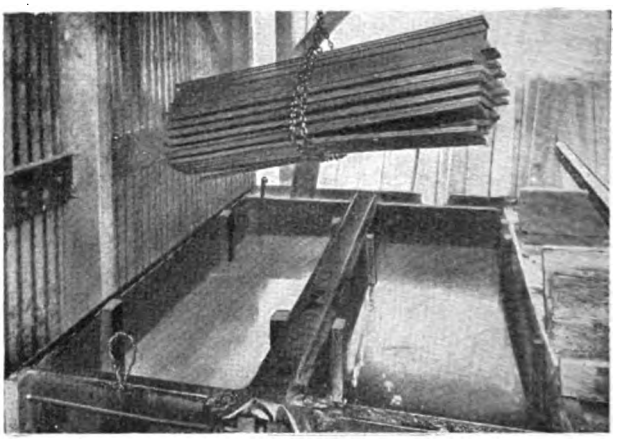


Ties Piled for Seasoning Before Treatment



Butt Treatment of Poles in an Open Tank



Open Tank Treatment of Lumber

Spray Treatment of Bridge Timbers

Brush Treatment of Telegraph Poles

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sation of water falls to a specified amount per cu. ft. of wood per hour, usually 1/6 lb. to 1/10 lb.

The vacuum is discontinued and the pressure applied until the desired absorption is obtained.

The object of the vacuum is to evaporate the water from the wood at a lower temperature than in the ordinary steaming or straight-boiling process.

Burnett. In general use for treating ties, lumber and timber with zinc chloride. Consists essentially as follows for seasoned wood:

a. Preliminary vacuum.

b. Zinc chloride solution is applied under pressure of 100 lb. to 175 lb. per sq. in., to approximate refusal.

For green timber a steaming period of one to five or more hours at about 20 lb. is usually applied before the vacuum. The strength of the zinc solution generally is so regulated that at refusal the timber will have absorbed from ¼ lb. to ½ lb., usually the latter, of dry zinc chloride per cu. ft.

Card. Used chiefly for ties, lumber and timbers. The essential parts of the process are:

a. The use of a mixture containing about 80 per cent of zinc chloride solution and 20 per cent creosote.

b. The method of keeping the zinc chloride and creosote mixed during treatment by means of a rotary pump, which draws the mixture from the top of the cylinder and returns it at the bottom through a perforated pipe.

The use of steaming, vacuum and pressure are the same as in the Bethell process. It is customary to inject about ½ lb. of zinc chloride and 2 to 3 lb. of creosote per cu. ft.

Lowry. (Empty Cell Process.) Used chiefly for creosoting air seasoned cross ties. Consists essentially of the following steps:

a. Without first drawing a vacuum, creosote at not to exceed 200 deg. F. is injected into the wood to refusal, or to a specific amount.

b. A quick vacuum is drawn to remove the excess oil from the timber.

The air imprisoned by injecting the oil without a preliminary vacuum expands during the final vacuum, forcing out a certain amount of the oil with it. The process is classed as an empty-cell process for this reason. The net absorption is from 6 lb. to 8 lb. per cu. ft.

Rueping. (Empty-Cell Process.) Used chiefly for ties and lumber. Consists of the following steps:

a. Cylinder, containing the wood is filled with compressed air, the pressure varying with the kind and condition of the wood.

b. Oil forced into cylinder gradually allowing the air to escape, but without reducing pressure.

c. When the cylinder is full of oil, the pressure is increased to a maximum of 150 lb. to 200 lb. per sq. in. and held to refusal, or until the specified absorption is obtained.

d. The oil is drained and the vacuum is drawn to remove excess of oil from the wood.

If green timber is treated, it is first artificially seasoned by steaming, boiling, or boiling under vacuum, before the air pressure is applied. The net absorption is usually 4 lb. to 6 lb. per cu. ft.

Steaming. (Colman Process.) Used almost exclusively for the treatment of Douglas fir piles. Consists essentially of the following steps:

a. The timber is steamed at a pressure of 90 lb. to 100 lb. per sq. in. for 3 to 10 hours.

b. The steam is then released and the vacuum is drawn until the timber is considered seasoned. This sometimes requires 18 to 20 hours. The temperature within the cylinder during the vacuum period is usually maintained above 200 deg. F.

c. Oil is injected at a maximum pressure of 100 lb. to 150 lb. per sq. in. until desired absorption is obtained.

A. R. E. A. Specifications for the Preservative Treatments

The following general requirements and specifications for the various chemical processes for the preservation of timber have been adopted by the A. R. E. A., the preliminary portion of each specification following closely the U. S. R. A. specifications.

General Requirements: The general requirements apply to each of the treatments:

If used in specifications for the purchase of treated material, these general requirements should be followed by the specification for the particular treatment desired.

Material should not be treated until seasoned. If it arrives at the treating plant in a seasoned condition ready to treat, it may be loaded direct from the cars to the trams; otherwise, it shall be stacked. If ties, they shall be stacked in layers of 1 or 2 and 7 to 10, depending on the width of the ties; if piles or lumber, they shall be stacked to insure even and proper seasoning—with alleys at least 3 ft. wide between rows of stacks extending between tracks, and at least 6 in. off the ground on treated sills. The space under and between the rows of stacks at all times should be kept free of rotting wood, weeds or rubbish. The yard should be so drained that no water can stand under the stacks, or in their immediate vicinity.

Since the seasoning varies with the latitude, time of year, the exposure and peculiarities of the season, it is essential to establish by experiment the seasoning period usually required to enable each class of timber to best receive treatment. Material piled for seasoning should be closely watched, and not allowed to overseason or to deteriorate. No material should be treated which does not conform to the requirements of the specifications as to shakes, checks, soundness, etc. Material which shows signs of checking should be provided with "S" irons, bolts, or other devices, in order to prevent, during or after treatment, further checking that would be liable to render it worthless.

Where ties are to be adzed or bored for subsequent insertion of spikes, or application of tie plates, such adzing and boring should in all cases be done before treatment.

Specification for the Preservation of Wood with Zinc Chloride

Except when ordered otherwise by the railway representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc-chloride shall contain at least 94 per cent soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required.

The material shall retain an average of 0.5 lb. of dry zinc chloride per cu. ft., which shall permeate all of the sapwood and as much of heartwood as practicable, and no charge shall retain less than 90 per cent, nor more than 110 per cent of this quantity.

The treating solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption that is practicable, and shall be thoroughly mixed before use. Its strength shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, will usually be satisfactory. For example: With red oak the strength shall not exceed 4 per cent, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood it shall not exceed 2 per cent, and the volume injected shall be not less than 40 per cent. The amount of solution retained shall be calculated from readings of working tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

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Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 lb. per sq. in., the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 in. shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced, the cylinder shall be drained of condensate, and if the vacuum is broken, a second one as high as the first shall be created. The preservative shall be introduced, without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised and maintained at a minimum of 125 lb. per sq. in. until the required quantity of preservative is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 lb. or more per sq. in. The temperature of the preservative during the pressure period shall be not less than 130 deg. F., nor more than 190 deg. F., and shall average at least 150 deg. F. After the cylinder is emptied of preserving solution, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by analysis. The "iodine-potassium ferricyanide starch" color reaction test to determine the penetration by its visibility will generally be satisfactory.

From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting treated plugs.

The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analysis and tests required in this specification.

Zinc-Tannin Treatment

The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained. The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cu. ft. of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 5 per cent.

The solution shall be heated to a temperature of not less than 140 deg. F. before admission to the cylinder. If the cylinders are provided with steam coils, steam shall be maintained in these coils during the entire treatment.

The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

After the required amount of zinc-chloride has been injected, this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off, and a 2 per cent solution of tannic acid, made by mixing 6⅔ lb. of 30 per cent extract of tannin with 100 lbs. of water, run in, and a pressure of 100 lb. produced and maintained one-half hour. This shall then be run off, a 1 per cent solution of glue (made by dissolving 2-1/10 lb. of glue containing 50 per cent gelatine in 100 lb. water) shall be admitted to the cylinder, and a pressure of 100 lb. produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their organized strength in these elements.

The zinc chloride used shall be acid free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent solution zinc chloride, and in any solution specified the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required.

Specification for the Preservative Treatment of Wood with Creosote Oil (Full Cell Process).

Except when ordered otherwise by the railway representative, the material shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the A. R. E. A.:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

The material shall retain the amount of creosote oil necessary to permeate all of the sapwood and as much of the heartwood as practicable. The quantities specified may vary from 10 lb. per cu. ft. for material from needle-leaved trees from which most of the sapwood has been removed to 24 lb. per cu. ft. for piling which had wide sapwood. The quantity of creosote oil retained shall be calculated, on the basis of 100 deg. F., from readings of working tank gages or scales, or from weights of at least one-tenth of the material on a suitable track before and after treatment, checked as may be desired by the railway representative.

After the material is placed in the cylinder, a vacuum of at least 22 in. shall be maintained until the wood is as dry and as free of air as practicable. The creosote oil shall then be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 lb. per sq. in. until the required quantity of preservative is injected into the material, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170 deg. F., nor more than 200 deg. F., and shall average at least 180 deg. F. After pressure is completed and the cylinder emptied of preservative, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rails sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railway. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

When permission is given to prepare material for treatment by steaming instead of seasoning by air, it shall not be subjected to pressures or temperatures for periods sufficient to injure the wood.

Specification for the Preservative Treatment of Wood with Zinc Chloride and Creosote Oil (Card Process)

Except when ordered otherwise by the railway representative, the material to be treated shall be air-sea-

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soned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the quantity of zinc chloride required.

The creosote oil shall meet the standard for grade 3 creosote oil.

The material shall retain an average of 0.5 lb. of dry zinc chloride and 3 lb. of creosote oil per cu. ft., which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of these quantities per cu. ft.

The preserving mixture shall be composed of the volumetric proportions of creosote oil and of zinc chloride solution of the necessary strength which are required to obtain the specified retention of the preservatives with the largest volumetric injection that is practicable, and shall be agitated in the working tank and cylinder so as to insure thorough mixing before and while the cylinder is being filled with preservative and while the preservative is being injected into the material. The strength of the zinc chloride solution shall not exceed 5 per cent and shall be determined by analysis. Chemical titration —using a silver-nitrate solution with potassium-chromate indicator, before the zinc chloride solution is mixed with the creosote oil will usually be satisfactory. For example: With red oak the proportions shall be not less than 77 per cent of 5 per cent zinc-chloride solution and not more than 23 per cent of creosote oil, and the volume injected shall be not less than 20 per cent while with pine having a large percentage of sapwood they shall be not less than 88 per cent of 2.5 per cent zinc-chloride and not more than 12 per cent of creosote oil, and the volume injected shall not be less than 40 per cent. The quantities of preservatives retained shall be calculated from readings of working tank gages or scales and from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railway representative.

Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 lb. per sq. in. the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 in. shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced the cylinder shall be drained of condensate, and if the vacuum is broken a second one as high as the first shall be created. The preserving mixtures shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 lb. per sq. in. until the required amount of preservatives is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 lb. or more per sq. in. The temperature of the preservative during the pressure period shall be not less than 170 deg. F., nor more than 200 deg. F., and shall average at least 180 deg. F. After the cylinder is emptied of preserving mixture, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by analysis. The "iodine-potassium ferricyanide starch" color reaction test to determine the penetration by its visibility will generally be satisfactory. From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analysis and tests required in this specification.

When water gas tar solution instead of creosote is used, it shall meet the following requirements:

The oil shall be a water gas tar product, of which at least sixty per cent shall be a distillate of water gas tar and the remainder shall be refined or filtered water gas tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent water.
2. It shall not contain more than 2 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38/15.5 deg. C. shall not be less than 1.03 nor more than 1.07.
4. The distillate, based on water free oil, shall be within the following limits:
   Up to 210 deg. C., not more than 8 per cent.
   Up to 235 deg. C., not more than 20 per cent.
   Up to 355 deg. C., not less than 60 per cent.
5. The specific gravity of the fractions between 235 deg. C. and 315 deg. C. shall not be less than .98 nor more than 1.02 at 38/15.5 deg. C.
6. The residue above 355 deg. C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.
7. The oil shall not yield more than 10 per cent coke residue.
8. The foregoing test shall be made in accordance with the standard methods of the A. R. E. A.

When a distillate of water gas tar is used, it shall meet the following requirements:

The oil shall be a distillate of water gas tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent of water.
2. It shall not contain more than 0.5 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38/15.5 deg. C. shall be not less than 1.02.
4. The distillate, based on water free oil, shall be within the following limits:
   Up to 210 deg. C., not more than 5 per cent.
   Up to 235 deg. C., not more than 25 per cent.
   Up to 355 deg. C., not less than 70 per cent.
5. The specific gravity of the fractions between 235 deg. C. and 315 deg. C. shall not be less than .98 nor more than 1.02 at 38/15.5 deg. C.
6. The residue above 355 deg. C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.
7. The oil shall not yield more than 2 per cent coke residue.
8. The foregoing tests shall be made in accordance with the standard methods of the A. R. E. A.

Specification for the Preservative Treatment of Wood with Creosote Oil (Empty-Cell Process with Final Vacuum), Lowry Process

(See U. S. Patents 707, 799 and 831, 450.)

Except when ordered otherwise by the railway representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be confined in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

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The preservative used shall be the one most suitable of the following standards of the A. R. E. A.:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

The material shall retain an average of at least 6 lb. of creosote oil per cu. ft. for cross-ties and 10 lb. per cu. ft. of other material, and no charge shall retain less than 90 per cent nor more than 110 per cent of the quantity per cu. ft. that may be specified. The quantity of preservative retained shall be calculated, on the basis of 100 deg. F., from readings of working-tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railway representative.

After the material is placed in the cylinder, the preservative shall be introduced, at not over 200 deg. F., until the cylinder is filled.

The pressure shall be raised and maintained until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum. The pressure and temperature within the cylinder shall be so controlled as to give the maximum penetration by the quantity of preservative injected. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at last 22 in. promptly created and maintained until the quantity of preservative injected is reduced to the required retention.

At least once each day the railway representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gages necessary to accurately indicate and record conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Specification for the Preservative Treatment of Wood with Creosote Oil. (Empty-Cell Process with Initial Air and Final Vacuum) Reuping Process

Except when ordered otherwise by the railway representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of air and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the A. R. E. A.:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

The material shall retain an average of at least 5 lb. of creosote oil per cu. ft., which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of the quantity per cu. ft. that may be specified. The amount of preservative retained shall be calculated, on the basis of 100 deg. F., from readings of working-tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder it shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of preservative necessary to insure the required retention. For example: With red oak pressures of 40 lb. to 60 lb. for 30 minutes, while with pine having a large percentage of sapwood pressures of 70 lb. to 90 lb. for 30 minutes will be required. The preservative shall then be introduced, the air pressure being maintained constant until the cylinder is filled. The pressure shall be gradually raised to at least 150 lb. per sq. in., and maintained until all of the sapwood and as much of the heartwood as practicable are saturated, or until the railway representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170 deg. F., nor more than 200 deg. F., and shall average at least 180 deg. F. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 in. be promptly created, and maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification. (See Page 721, 758 and 778.)

X

XYLOTRYA. A wood-boring mollusk which lays eggs free in the water. They hatch to form small free-swimming bivalve larvae, which attach themselves to timber by a foot and then bore into the wood and form lime-lined galleries, averaging ⅜ in. in diameter and 3 in. to 6 in. long, although they may reach an inch in diameter and over a foot in length.

The entrance at the surface of the wood is no larger than a pin hole, enlarging within the timber to keep pace with the growing animal, the galleries being closely intertwined and very numerous. (A. W. P. A.)

Z

ZINC CHLORIDE. A salt strongly toxic to wood-destroying fungi, first used as a timber preservative in England about 1838, shortly afterwards in the United States and now in general and increasing use, especially for the preservation of cross ties laid in latitudes where the climate is comparatively dry.

Being soluble in water, it tends to leach out if the treated timber is placed in direct and long-continued contact with moisture, or in an excessively wet climate. This preservative is obtainable as a solid or a liquid. As a solid it is in a fused state containing at least 94 per cent of water-soluble zinc chloride. It should be slightly basic, free from acids, iron or other inorganic impurities.

The concentrated solution is about one-half water, this being the form in which it is injected into timber. Zinc chloride is not a water proofing wood preservative but depends entirely on its poisonous effects on wood destroying fungi to protect the timber impregnated with the salt. See Wood Preservation. (See page 697.)

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The
General Section

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A

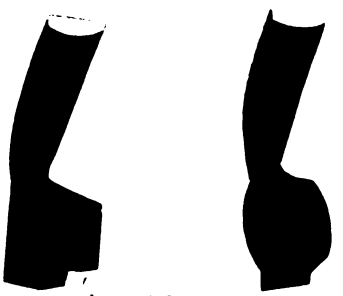
ABRADANT. A metal usually in the form of a powder used for grinding; as emery, sand or glass.

ACETONE. A colorless liquid, obtained as a by-product in the distillation of wood alcohol, employed as a storage agency for acetylene, which is used for lighting, cutting and welding. Acetone dissolves many times its volume of acetylene gas, the quantity depending upon the air pressure.

ACETYLENE. A colorless gas, C_2H_2, obtained commercially by bringing water into contact with calcium carbide. Acetylene burns with a brilliant white flame, has a distinctive ethereal odor, is slightly poisonous and is explosive under pressure of more than two atmospheres.

Acetylene is used as an illuminant in flare lamps to light night wrecking operations and as a constituent of gases employed in the welding and cutting of metals, such as building up frog points in place and cutting bridge steel to any desired length. The problem of safe storage and transportation of acetylene has been solved by the use of acetone in asbestos-filled containers under pressure. The containers are charged at central plants from which they are distributed for use and to which they are returned when empty for recharging. The container thus prepared may be charged and recharged with acetylene gas, the liquid acetone remaining in the asbestos and dissolving successive charges of acetylene without necessity of renewal.

ADZ. A wood hewing tool, somewhat like an ax, but having the blade set at right angles to the handle and bent to a curve almost corresponding to the sweep of the tool through the air when used.



Carpenter's and Railroad Adzes
(See Pages 707, 830 and 832)

The railway adz is a heavy full-headed tool, used principally to dress cross ties to a smooth bearing in track for rails or tie plates. It should be made of tough steel, yet hard enough to hold an edge. The handle should be well shaped and so set that the tool will be properly hung or balanced.

Lighter adzes are much used by bridge and building carpenters in the sizing of timbers for wooden bridges and buildings.

AERATION. The impregnation of water with the carbonic acid gas contained in air by passing air through the water. This may be done by means of compressed air pumps which commonly force the air through pipes immersed in the water, or by spraying the water into a confined air-filled space. Aeration tends to make drinking water palatable. In some degree aeration is effected during the expansion of water for purposes of pumping it. See Air Lift Pump. (Water Service Section).

ALLOY. A substance possessing the general physical properties of a metal but consisting of two or more metals, or bodies with non-metallic bodies in intimate mixture, solution, or combination with one another, forming a homogeneous fluid when melted. See Steel, Alloy. Also Steel, Special.

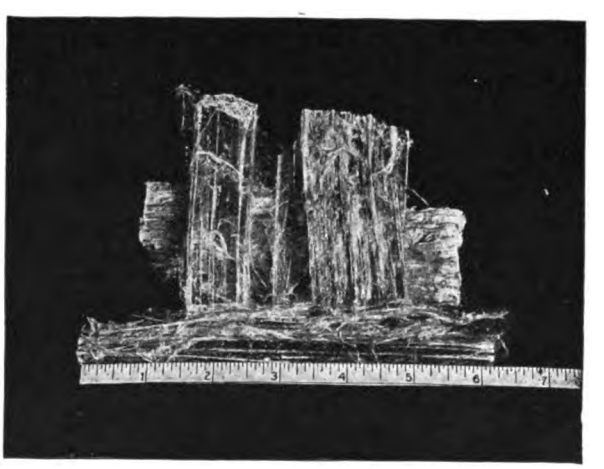
ALUMINUM. A silvery white metal, soft, very light in weight, ductile, malleable, strong, non-corrosive and a good conductor of heat and electricity. It occurs in nature in combination with many substances. In its various compounds aluminum is estimated to form one-twelfth of the earth's crust.

The Thermit process used for welding iron and steel depends upon the affinity which powdered aluminum and iron oxide have for each other. These substances being finely mixed and then ignited, the temperature suddenly rises to about 5400 deg. F. and white-hot fused iron results which will melt any ordinary casting or forging. The process is mainly used for welding breaks in large pieces of metal such as those in a crossing frog.

ANNEAL. To subject metal to great heat and to subsequent slow cooling to soften and toughen or temper it. Rolled, forged or cast steel, after becoming cold may contain internal strains due to the accelerated cooling of the small parts and sections. In order to relieve these strains and possible changes in the structure of the metal, such pieces are often reheated to a high temperature and allowed to cool slowly, possibly with the furnace. Annealing is a form of heat treatment. In general, heat treatment consists of reheating the steel to a certain temperature well above its critical point and quenching it in a bath of oil, water or sometimes lead. Following this it is then annealed, or tempered. See Steel.

ASBESTOS. An incombustible, fibrous material which is mined in Europe, South Africa, Canada and the United States. It varies in color from silky white to gray green.

At least 90 per cent of the world's supply of asbestos comes from open pit mines in the Serpentine belt of eastern Quebec where it occurs in two varie-



Asbestos Fibre

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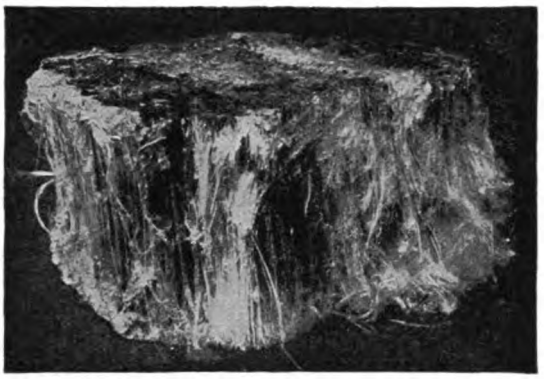
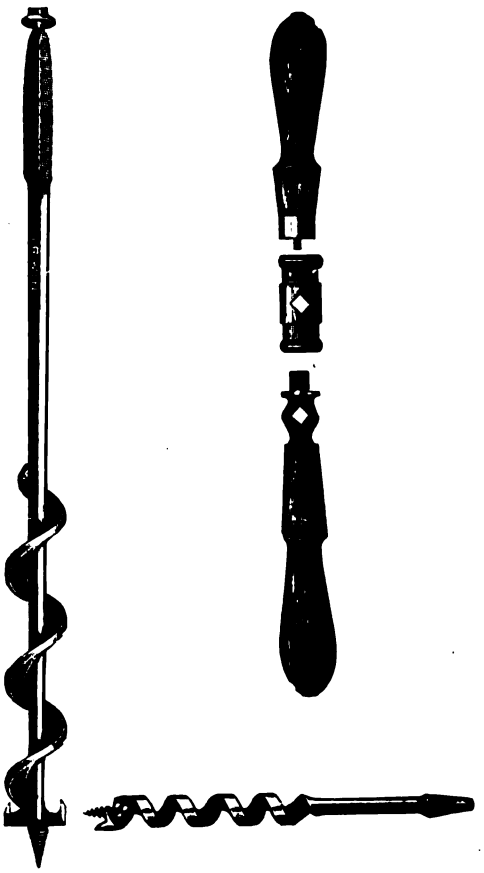


Crude Asbestos

ties; crude or vein, and fibrous. Asbestos is used largely in the manufacture of insulating and fireproofing materials, for pipe and boiler coverings, fireproof paints and cements, packings, gaskets, shingles, roofings, mill boards and building papers. Asbestos shingles are made of a combination of pulverized asbestos and Portland cement.

AUGER, CARPENTER'S. A tool used for boring holes in wood.

There are various kinds of augers, the type in general railway use consisting of a cutting and boring portion called a bit formed from the lower portion of the long, straight, steel stem or shank and a cross-head or handle placed at the top of the shank. The cutting and boring portion consists of a conical, threaded, gimlet point which serves as the guide and advance-boring end of an upper spiral lipped portion, the opposite bottom whorls of which are sharpened to cut out a circular section which the following inclined edges lift in two shavings with a continuously deepening spiral action, thus making a cylindrical hole of the circumference of the bit. The cross handle is usually of turned hard wood held to the top of the shank in an eye or tee.



Auger Bits and Handle

Another type is an all-steel crank-shank auger, about 3 ft. 9 in. long over all, having a gimlet advance point, a spiral lipped cutting and boring bit and a handle at the top for holding and guiding the auger.

ANVIL. A blacksmith's steel working block on which metals are hammered and shaped.

This device consists of a heavy rectangular sectioned steel casting having concave sides and ends,

Blacksmith's Anvil

a top face which is broad, flat and tapering at one end and to which the base of a conical projection is fastened. In the main casting back of the base of the cone are holes for the insertion of cold chisels, punches, etc.

Anvils are commonly used as blocks on which to repoint and repair tools such as picks, track chisels, etc., and to work metal during bridge erection. The anvil is usually placed in the tool car, where repairs to all bridge gang tools are made.

AX. A tool for splitting wood, hewing timber felling trees, etc.

Double and Single Bit Axes

It consists of a thin, wide, wedge-shaped steel head having an arched bit or cutting edge, a rectangular striking surface, an eye in which the

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wooden handle, about 36 in. long, is securely wedged in such a manner that the cutting edge is in the plane of the sweep of the tool. The type of ax in general railway use is a heavy full-headed single bitted tool of tough steel with a bit especially tempered to hold an edge and withstand hard usage. Double bit axes having two opposite cutting edges are sometimes used for hewing ties.

AX (Hand). A short handled, broad bladed ax used for hewing timber, chopping wood, etc.

Hand Ax

This tool, sometimes called a broad hatchet, is designed to be used with one hand and consists of a thin, wide, wedge-shaped steel head having a straight broad blade or cutting edge beveled on one side, a rectangular striking surface and a wooden handle 18 in. to 24 in. long.

B

BACK FILL. Earth or other material placed about the footings and walls of culverts or at the ends of bridges within the limits of the roadway cross-section to replace material removed during construction. See Bridge. Also Culvert, (Bridge Section).

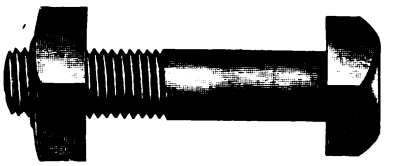
BESSEMER PROCESS (Steel Making). The manufacture of steel by blowing air through a molten bath of pig iron in a converter to oxidize the metalloids rapidly, while the heat produced by their combustion is utilized to raise the temperature of the bath sufficiently to have it liquid at the end of the process. See Steel.

BEVELED WASHER. A taper washer used to afford a flat bearing for a bolt or nut which would bear against an inclined surface: that is a surface not at right angles to the axis of the bolt. See Frog, (Track Section).

BLOCK, TACKLE. A mechanical contrivance consisting of one or more grooved wooden or metal pulleys mounted on an axle held in a casing which is also provided with a hook, an eye or a clevis by which it may be attached. A block is used to transmit power or to change the direction of motion by means of a rope or a cable passing around the movable pulleys and running through the grooves. A block may be single, double, treble, quadruple, etc., according to the number of pulleys on the axle. Standing blocks are those fastened to fixed objects, while running blocks are attached to objects to be moved. Blocks are used on cranes, derricks, well drills and other load-lifting and moving contrivances. (See Page 768).

BOLT. A metallic pin or rod used to hold objects together and in place. It is provided with a head at one end and generally with screw threads at the other end to receive a nut.

Hexagon Head Bolt



Square Head Bolt

Bolts are used to hold the assembled parts of rail joints and other track devices in place. They are also used in bridges, buildings, machines and equipment. Various devices called bolts are really screws, nails or other forms of fasteners, such as drift bolts for fastening caps on piling of wooden bridges, carriage bolts or lag screws and slide bolts used to fasten doors of buildings. Bolts which require nuts usually have round, spheroidal, square or hexagon heads; the shanks are commonly cylindrical and the nuts are square or hexagonal in section. Machine bolt heads are, however, of various forms and combinations of shapes, depending on their use.

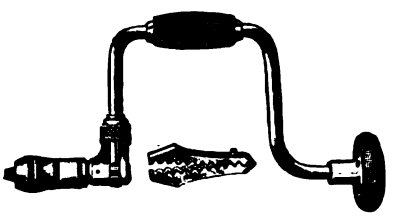
Bolts are made of a wide variety of metal, usually of iron or steel. Steel bolts are made of many grades of steel, depending on the use for which the device is intended and the forces which it is designed to resist. Some bolts are made of alloy steel, heat treated and oil quenched, with a view to the severe service track and heavy machinery bolts. See Bolt, Track, (Track Section).

BOND. The process of firmly uniting parts to form a strong structure. In block masonry bonding is accomplished by overlapping the stones, bricks, etc. In pouring concrete the unfinished surface is left rough and with protruding reinforcement, with a view to obtaining the firmest bond or adherence of the fresh to the older material when the construction is continued. New concrete is sometimes bonded to an existing concrete structure by means of anchor bolts which are so constructed that they may be driven with a wedging or spreading effect into holes drilled in the finished face of the masonry. See Masonry, (Bridge Section).

BOND STONE. A stone extending through a masonry wall from face to face to bind the members together.

BRACE AND BIT. A carpenter's two-piece wood-boring tool.

This device consists of a short, straight shanked auger or bit, secured at the shank end to the bottom of a crank-formed shaft in such a way that



Ratchet Brace

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by turning and pressing on the end of the shaft, the bit is screwed into the wood, turning out two spiral shavings and forming a round hole. The brace, which is detachable from the bit, is commonly provided at the bottom end with jaws which accommodate the identically-shaped square section heads of interchangeable bits of various bores. The top of the brace revolves freely in a metal or wooden disc designed for pressing the tool against the work while the crank shaft is turned by means of a loose hand-hold at the middle. See Auger, Carpenter's.

BRUSH HOOK. A large knife with a hooked blade for cutting brush.

A common type consists of a stout straight blade terminating in a hooked end and fitted to a straight

Brush Hook

ax handle. Another type consists of a broad, heavy, hooked blade, with a concave cutting edge and an eye at the heel end which holds the handle in a line parallel with and behind the cutting edge.

Brush hooks are used principally for cutting brush and weeds that cannot be cut with the ordinary scythe.

C

CABLE. A rope which is 10 in. or more in circumference. A cable may be made of hemp or some other vegetable fiber, or as is more usual, of a number of strands of drawn wires, or of chain which is equally strong. Cables are used as the main members of suspension bridges and elsewhere where great tensile strength, rigidity and durability are required. See Rope. Also Wire Rope.

CALKING. The process of filling the seams between timbers or steel parts of a structure to make them water or air tight as in cofferdams, caissons, pipe joints, etc. When the planed surfaces of planks or timbers are fitted together or steel plates are lapped and riveted to form a joint, seams are sometimes formed which are not impervious to water or air. In timber cofferdams and caissons the seams are commonly calked with strands of oakum or other materials while the seams of metal riveted plates are closed by slightly indenting one edge of the plate with a calking tool, the indentation having the effect of forcing the edge hard against the surface of the adjoining plate, thus filling the crevices which the rivets fail to close.

CAMP. A habitation furnished for maintenance of way laborers at a location convenient to their place of duty, usually on railway property close to the tracks.

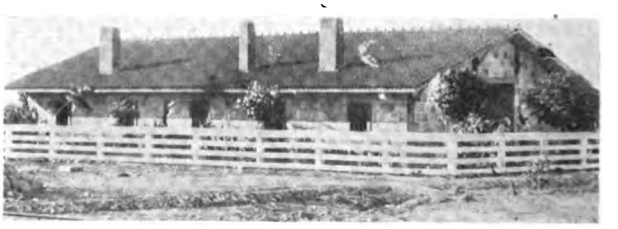
Comfortable housing for laborers so improves working conditions that it is considered an important factor in the problem of labor efficiency, to be developed in proper ratio with other maintenance expenditures. The facilities to be provided depend largely on the character and nationality of the labor employed as well as on the general labor conditions obtaining in the vicinity. The proper tendency is toward improvements in housing in proportion to inducements offered by manufacturing interests and other employers of labor.

Maintenance of Way Camp with Frame Bunk Houses

Tile Bunk House

Concrete Bunk House

Concrete Bunk House



Hollow Tile Bunk House

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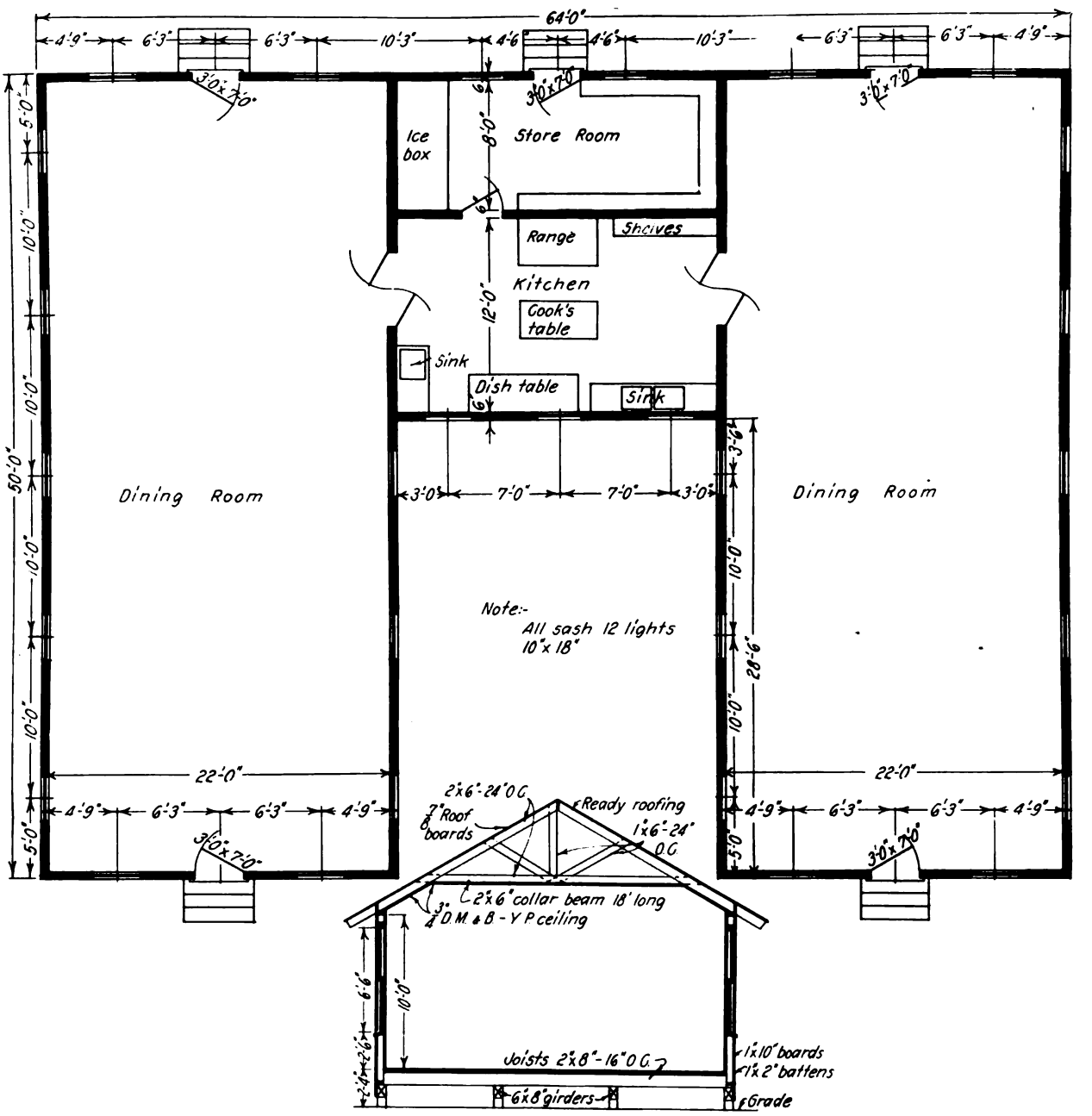
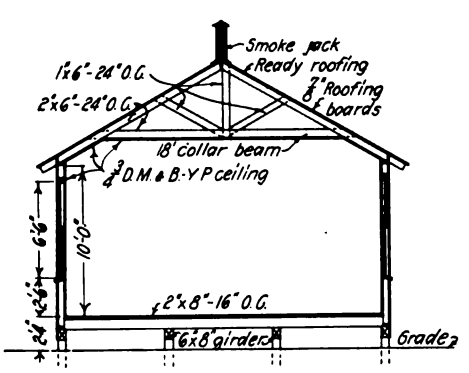
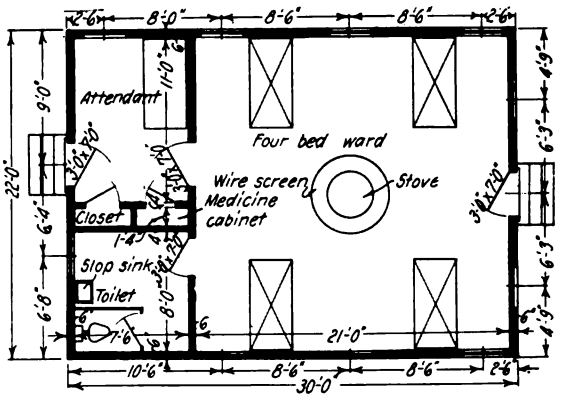


A. R. E. A. Permanent Camp. Typical Plan for Mess Hall





A. R. E. A. Permanent Camp. Typical Plan for Isolation Building

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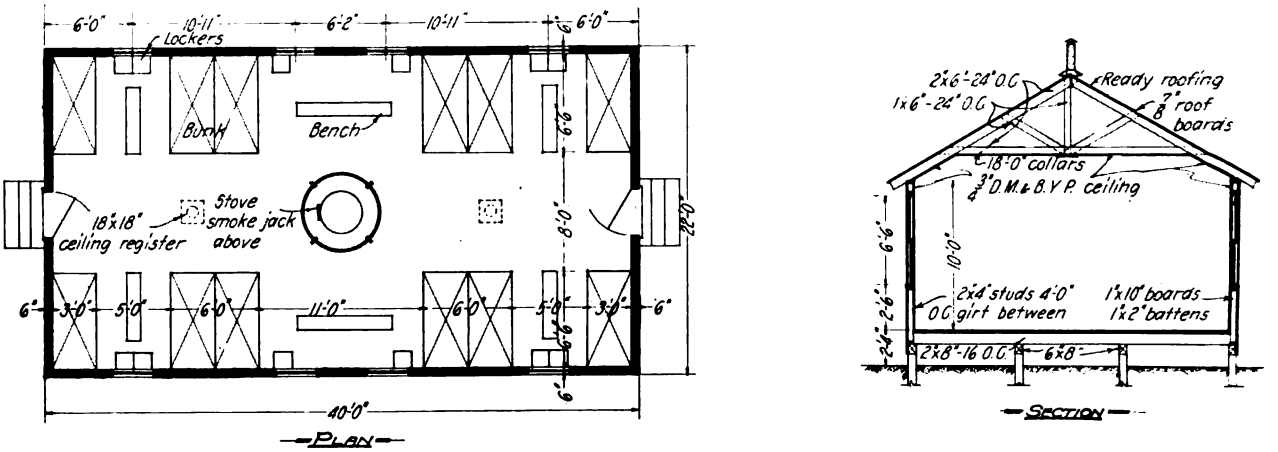
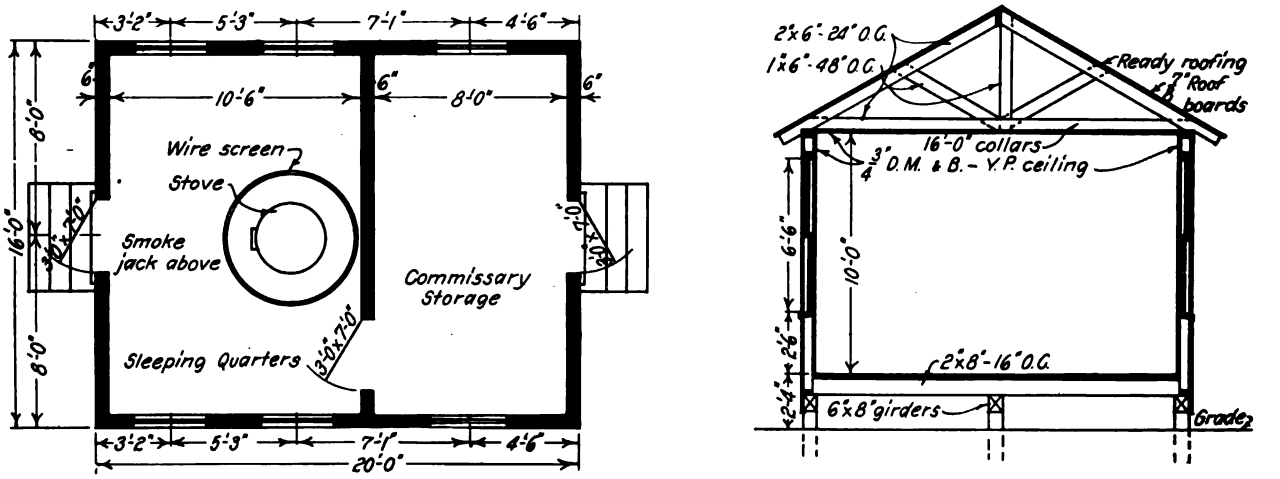
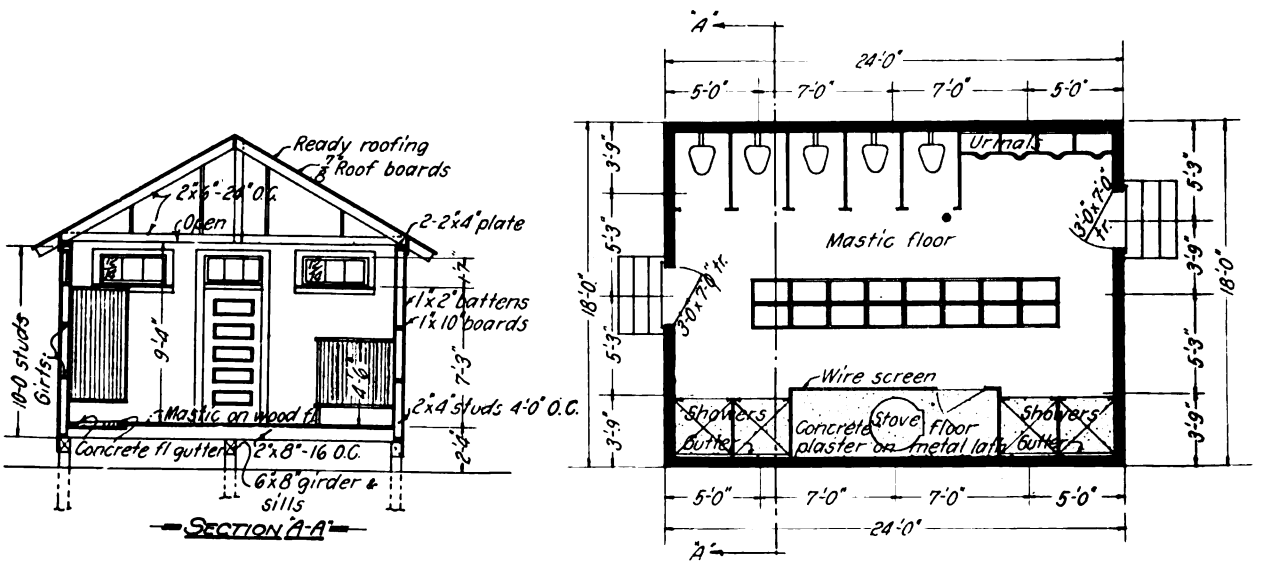


A. R. E. A. Permanent Camp. Typical Plan for Bunk House



A. R. E. A. Permanent Camp. Typical Plan for Commissary



A. R. E. A. Permanent Camp. Typical Plan for Lavatory

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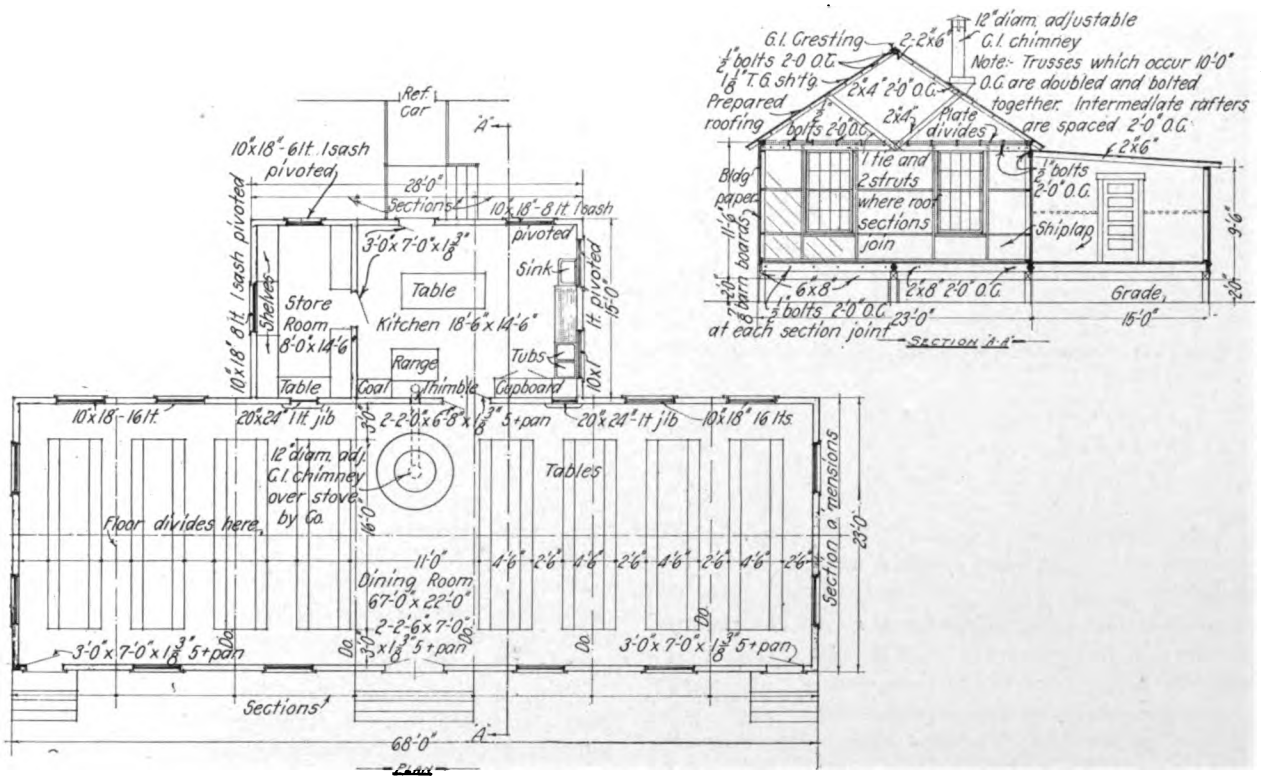
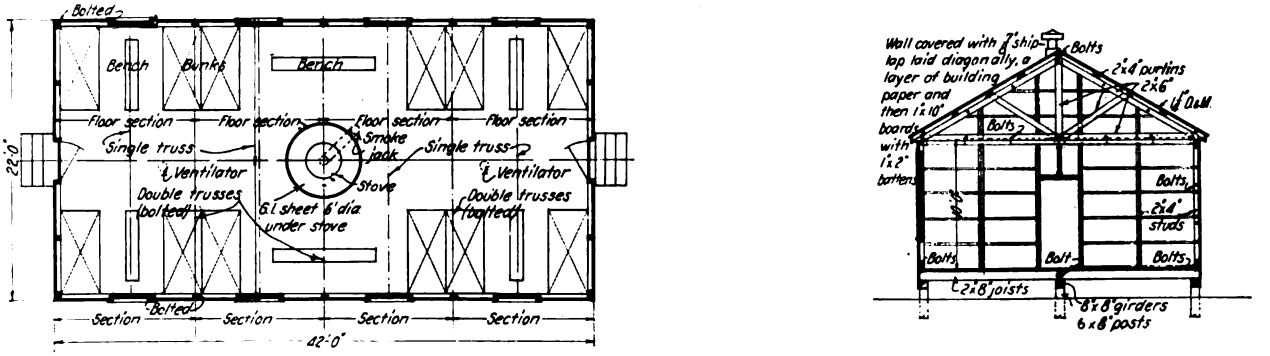
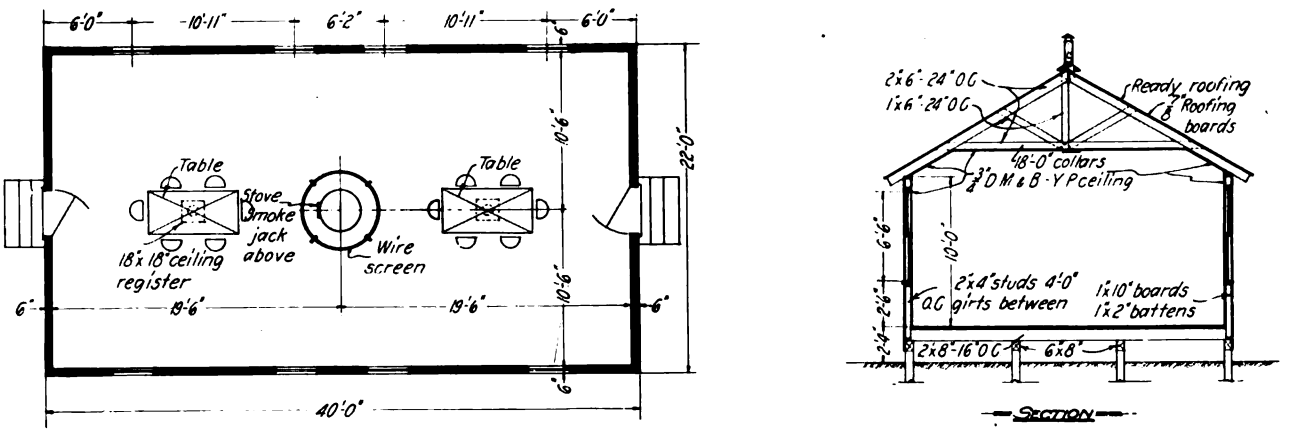


A. R. E. A. Temporary Camp. Typical Plan for Mess Hall



A. R. E. A. Temporary Camp. Typical Plan for Bunk House



A. R. E. A. Temporary Camp. Typical Plan for Lounging Building

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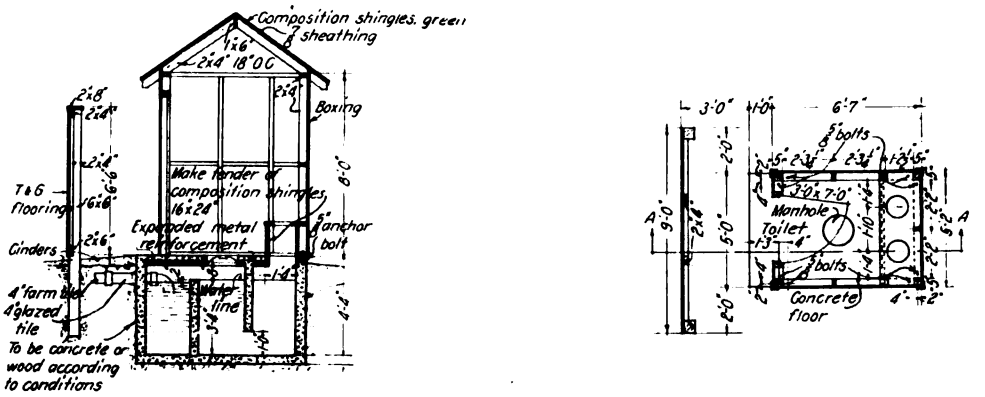


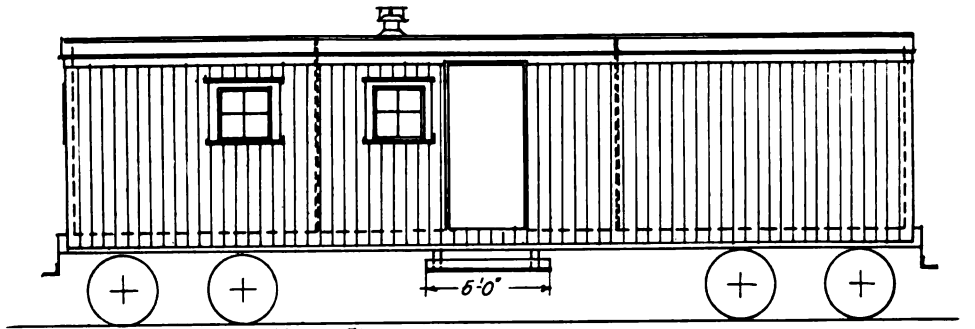
A. R. E. A. Temporary Camp. Typical Plan for Septic Closet

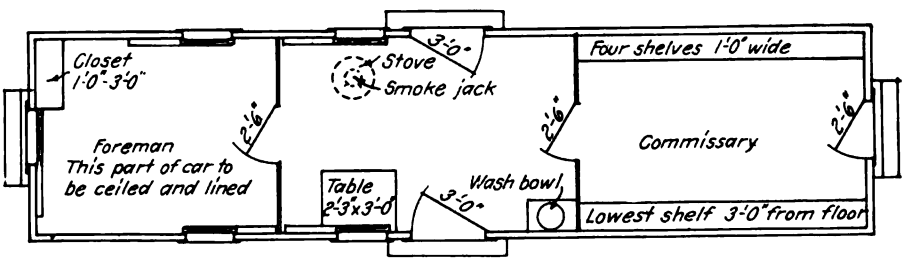
Camps are of two types, (1) temporary and (2) permanent. Temporary camps may consist of a collection of tents, but this manner of caring for labor is a makeshift common only in construction projects. The temporary maintenance camp in the common acceptance of the term consists of portable buildings usually of the sectional type, made to be readily erected and "knocked down" for transporting on cars. These knock-down sections are usually framed on 2 in. by 4 in. timbers with outside wall covering of pure iron, corrugated iron or wood, the latter being of 5/8 in. diagonal lining under outside vertical 5/8 in. barn boards and battens, with building paper for lining. The roof sections are covered with lumber and ready roofing while the floors are of 1 in. by 10 in. lumber on 4 in. by 8 in. joists. The buildings are set on suitable wood posts, metal pipes with thimbles being used for ventilation and chimneys.

Permanent camps are made of timber or of any of the more durable materials, usually of concrete with solid filled floors and roofs of dressed and matched boards covered with ready roofing.

While a small camp may be under one roof it is usual to erect several buildings according to the number of men to be housed. The tentative plans suggested by the A. R. E. A. committee on economics of labor include a mess hall, a lavatory with shower baths, washbowls and toilet facilities, a bunk house, a commissary, a lounging building and an isolation building. The mess hall and bunk house are generally the larger and more important structures of the group.

CAMP CAR. A car used as portable living quarters for workmen employed along a line of railway.





A. R. E. Camp Cars. Typical Plan for Foreman's and Commissary Combination Car

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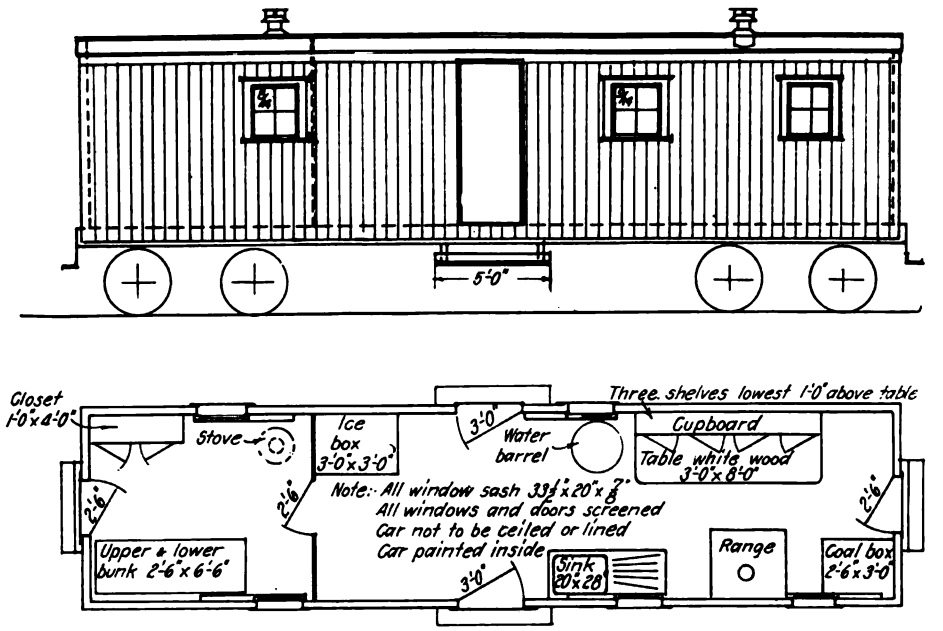
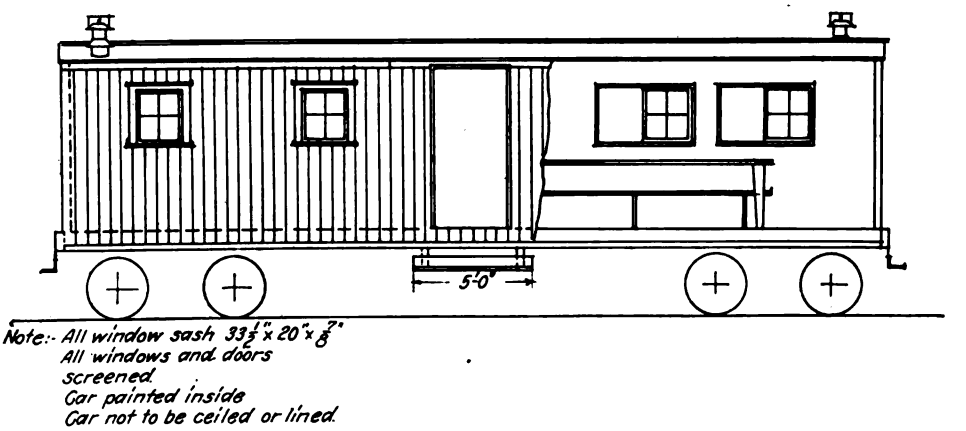
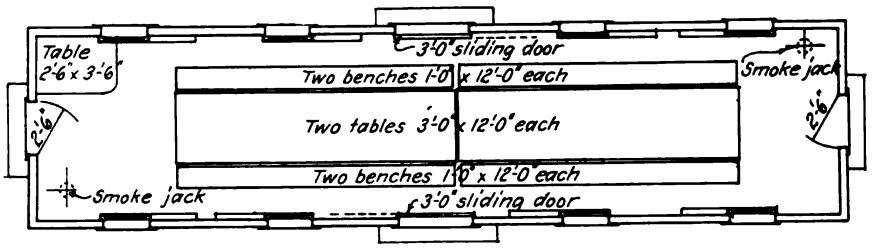


A. R. E. A. Camp Cars. Typical Plan for Kitchen Car





A. R. E. A. Camp Cars. Typical Plan for Mess Car

Camp cars ars usually box cars or sometimes passenger coaches which have been retired from revenue service and refitted with bunks or other camp equipment. In addition to a kitchen car, dining cars, several bunk cars and a foreman's car, a track gang of 50 men usually has a commissary car, a car for tools, a locomotive water tank and sometimes a lounging car. Bridge, building, water service and signal gangs are usually smaller, more permanently employed and similarly though somewhat better housed in cars suitable for habitation in winter. Water, fuel, ice and kerosene are usually furnished by the railway company for use in camp cars.

The maintenance of way of railways requires large forces of laborers during the summer season when a major part of the work must be done, the gangs being moved from place to place as the work progresses. To permit the men to live as near their

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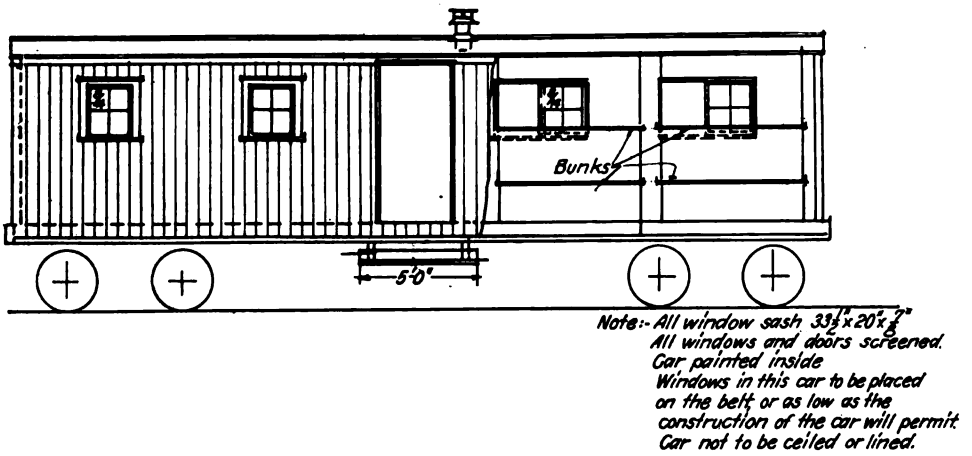
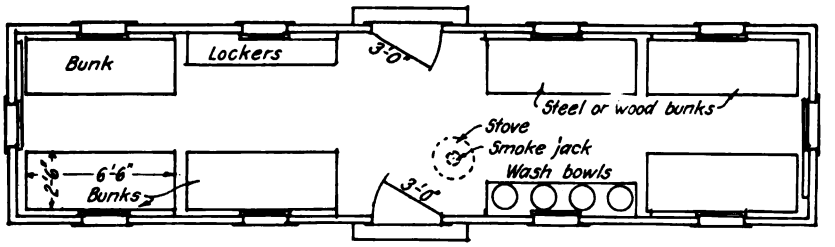
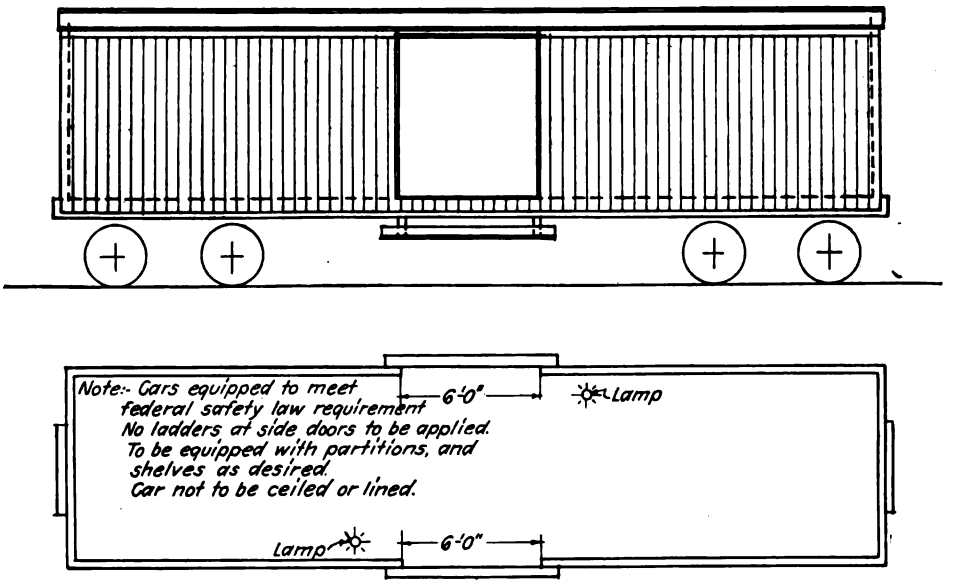




A. R. E. A. Camp Cars. Typical Plan for Bunk Car



A. R. E. A. Camp Cars. Typical Plan for Material Car

work as possible it is necessary to house them in camp cars, sometimes called boarding trains, which may be moved from siding to siding as required. An alternate solution of the problem is to provide camp houses. Some camps are permanent, but more are portable knock-down buildings. Labor can be better accommodated in camps than in cars with the further advantage of release of equipment and track room occupied by boarding trains. But the mobility of camp cars as compared with portable houses is of such importance that they are largely used for maintenance of way gangs.

No one method of feeding and housing can be made a standard for men of different nationalities who accept such service, as their standards of living are different and they require corresponding accommodations. Thus a Mexican brings his family, an Italian cooks his own food, while native white labor

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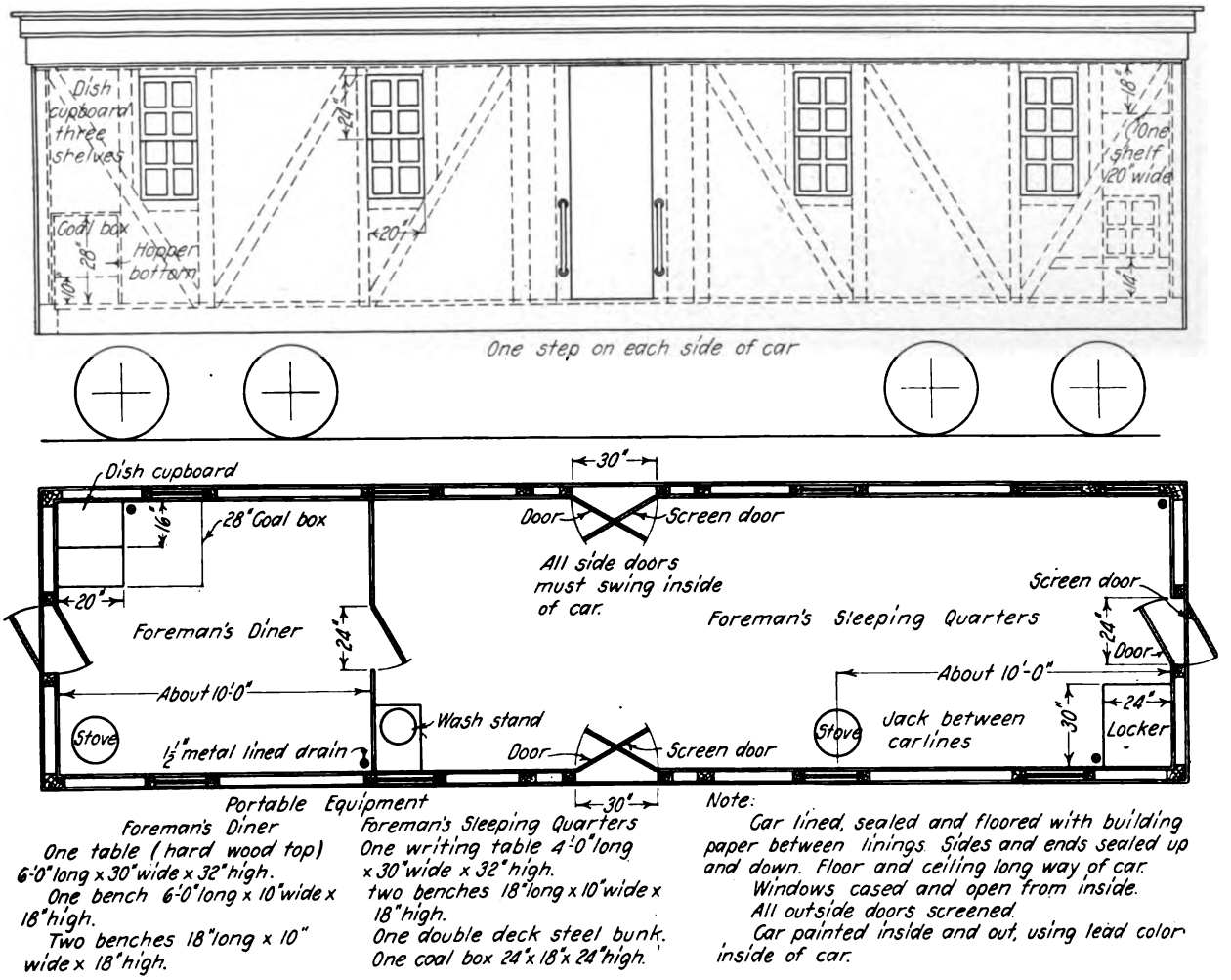

Standard Foreman's Car of the Chicago, Burlington & Quincy Boarding Train

requires the American standard of living and must be served with cooked food. While the permanent camp can be made more readily sanitary and comfortable, it is possible to maintain a fair standard of living in well appointed camp cars, with good food well cooked and with strict supervision over sanitary details. Modern fittings include steel bunks with linen and other bedding of good quality in well ventilated sleeping cars, arranged to accommodate 8 to 16 men each, the tendency being to limit the number of men in a car in order to promote healthfulness. A car is usually set aside to carry the men to and from their work, the lounging car sometimes being used for this purpose, thus minimizing the danger of accidents due to laborers riding in material cars, or standing on caboose platforms.

The comparative possibilities of establishing and maintaining a reasonably desirable and satisfactory standard of living conditions among the employees housed in maintenance of way boarding cars is dependent on a wide variety of local circumstances, of available equipment and of personnel. In many cases the territory covered by the extra gang includes a number of cities or towns employing many thousands of workmen in manufactories and in other lines of commercial endeavor in which the wages as well as the working conditions are more attractive to many men than the temporary employment in which they are engaged for the maintenance department. Usually the laborers with this viewpoint include some of the best men of the extra gang, men who have accepted temporary work only as an expedient and a stepping stone to permanent employment on the best terms possible and under the most favorable circumstances. Other extra gang laborers accept maintenance of way employment as one of many makeshifts. Having no responsibilities, they migrate at will, working only as sheer necessity demands, ever ready for a change in employment, easily dissatisfied and readily led by disturbers to new fields of better promise in the labor world. The nucleus of the track gang is commonly a group of laborers inured to the work and experienced in the railway labor field, who accept the boarding train life and the duties it involves from long habit and a sense of satisfaction in the companionship, the travel and the living conditions.

The attitude of these men depends largely on the personality and executive ability of the foreman and his assistants, and the excellence of the living arrangements afforded. Box car trains are not attractive as compared with the converted day coaches used on many railways. The box cars released to be fitted as boarding cars for company business are frequently short cars, without the best of trucks and springs or the tightest of roofs. They are preferably not converted until they have been thoroughly overhauled and repaired.

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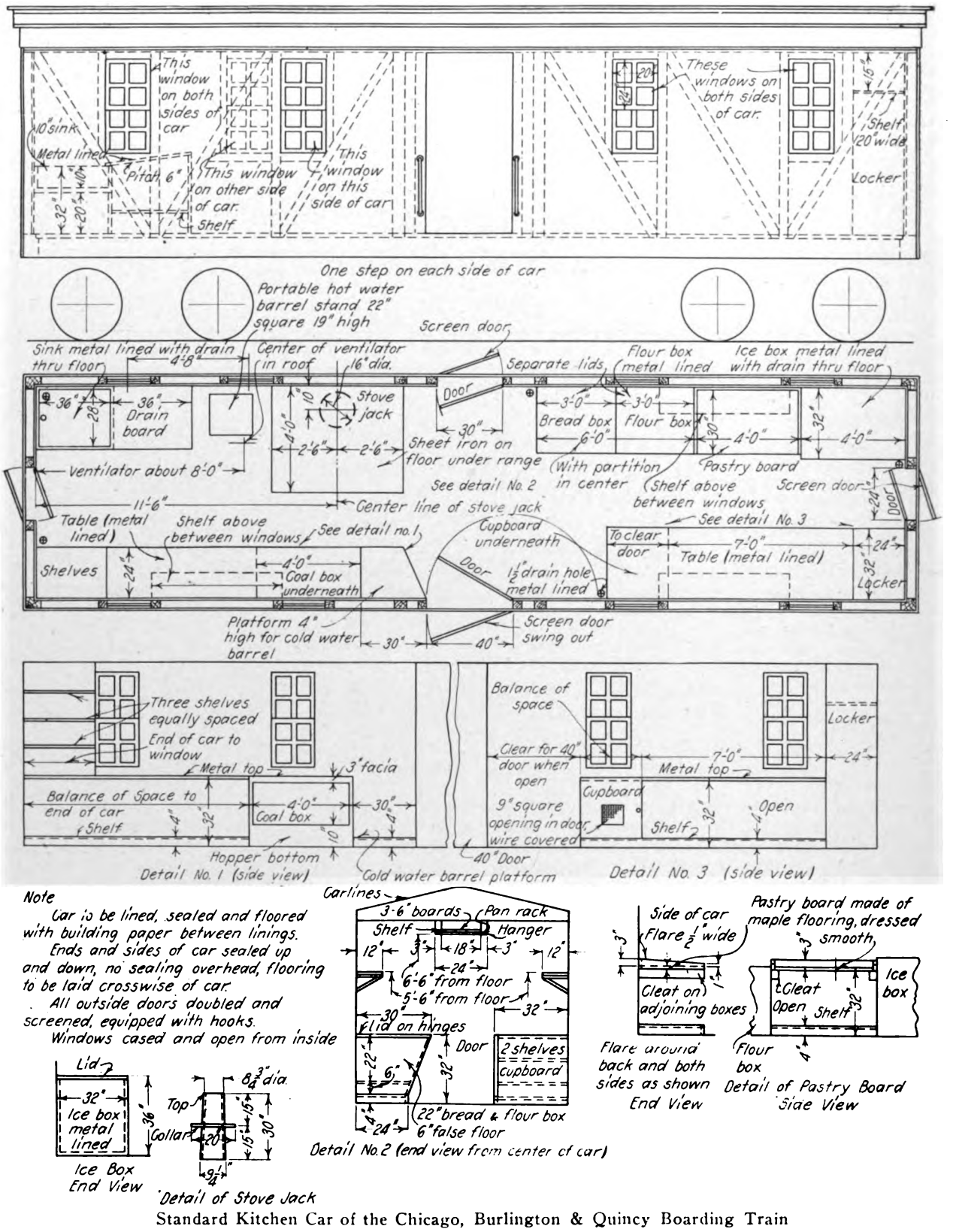

Standard Kitchen Car of the Chicago, Burlington & Quincy Boarding Train

Sometimes the necessary repairs are so extensive that they should be scrapped rather than rehabilitated for service. The refitted day coach usually is longer and a better riding vehicle than the box car and much appreciated by extra gang laborers. Wooden fittings, such as are frequently installed in the cars in railway shops have been superseded largely by the more modern metal facilities of well appointed boarding trains. The cleansing of sealed box cars to eradicate vermin is a difficult matter, especially in mid season during occupancy. The converted passenger coach is usually easier to clean, as it is tighter and may be more readily sealed during fumigation. If the beds and as many other

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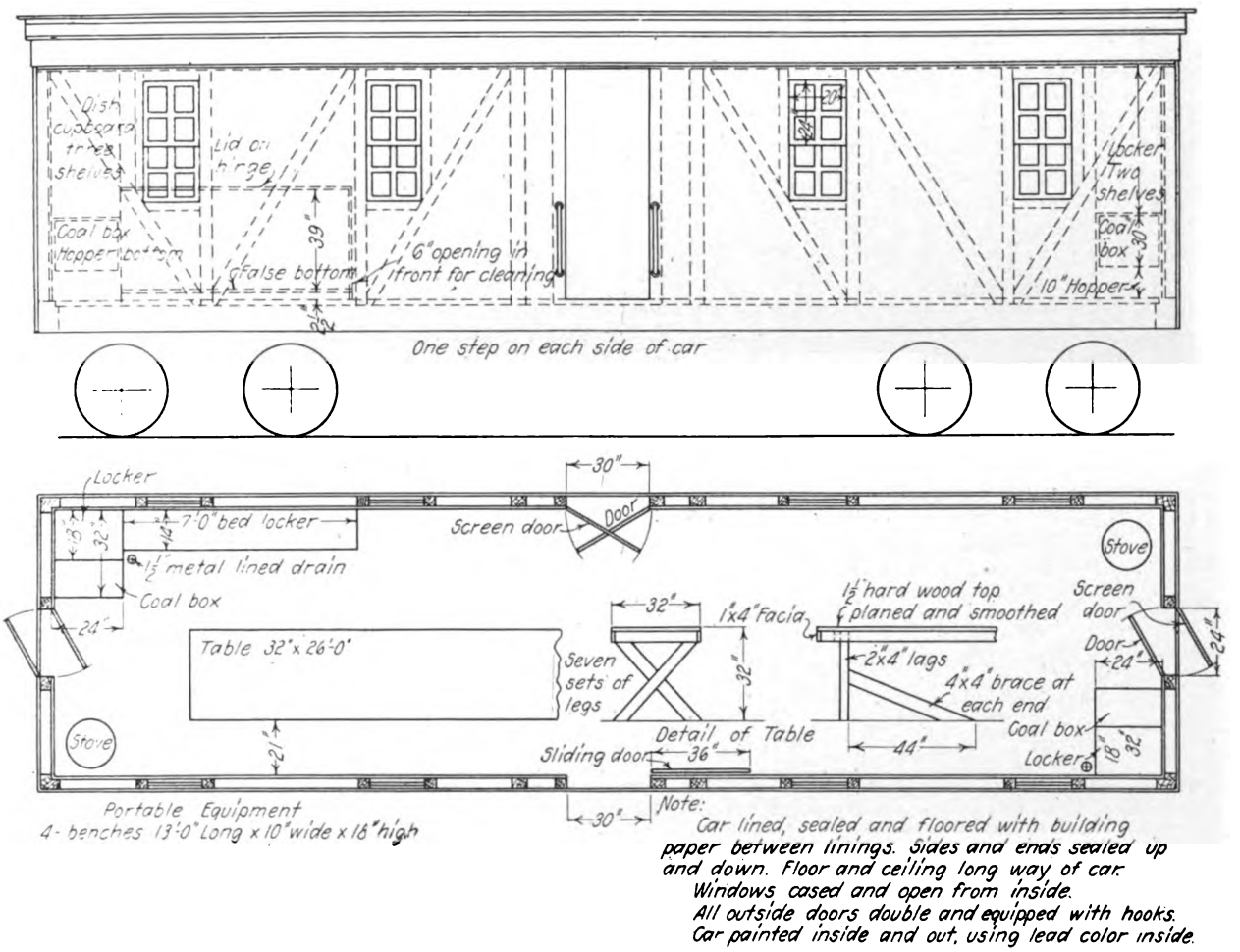

Standard Mess Car of the Chicago, Burlington & Quincy Boarding Train

MESS CAR

Article	
Bowls, Butter	10
Bowls, Sugar	10
Bowls, Soup	50
Cruets	8
Coffee Pots	10
Cups	55
Dish-ups, Large	36
Dish-ups, Medium	24
Dish-ups, Small	18
Forks	65
Knives	65
Pitchers, Milk	10
Pitchers, Syrup	10
Pitchers, Water	10
Pepper Dredges	10
Plates	65
Platters, Large	8
Platters, Small	8
Spoons, Table	75
Spoons, Tea	65

MESS CAR

Article	
Barrels, Water	2
Butcher Knives, Size	2-12 in.
Butcher Knives, Size	2-14 in.
Bread Pans, full	4
Cake Turners	2
Cake Pans	2
Cullender	1
Cleaver	1
China Cap	1
Salt Dredges	10
Saucers	5
Water Glasses	60
HOUSING	
Blankets	250
Basins	15
Ice Picks	2
Brooms	12
Cots, Single	7
Cots, Double Deck (furnished by Railway Co.)	25
Lamps	24
Chimneys	36
Mattresses	60
STORE	
Ice Tongs	2
Meat Block	1
Scale, Platform	1
Meat Saw	1
Oil Cans	2-½ Gal. 1-5 Gal.

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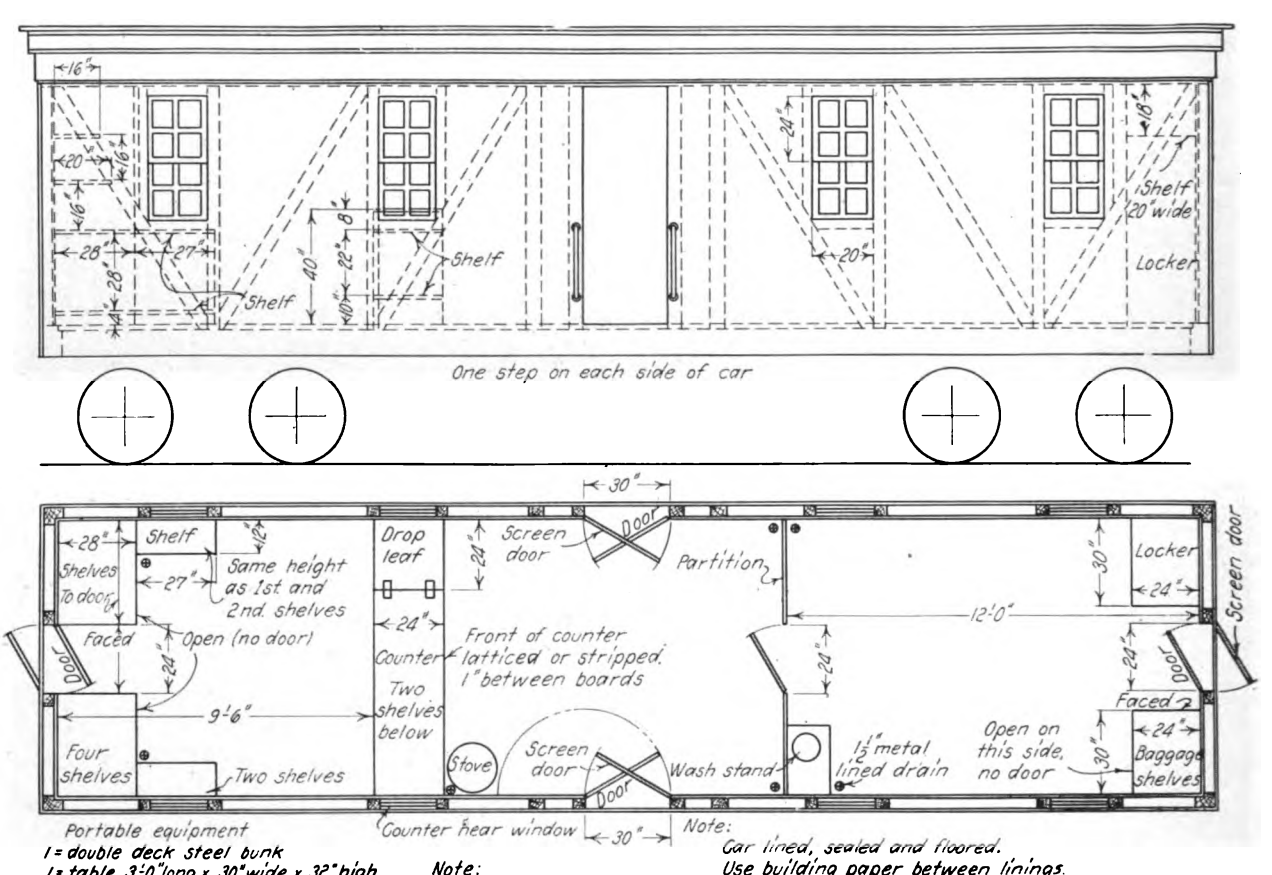

Standard Store Car of the Chicago, Burlington & Quincy Boarding Train

KITCHEN CAR

Article	
Cake Griddle	1
Dippers	12
Dish Pans, Large	2
Dish Pans, Small	1
Egg Whip	1
Flour Scoops	2
Flour Brush	1
Flesh Forks	2
Fire Shovel	1
Frying Pans	2
Funnels	1
Faucet	1
Galv. Tubs	3
Galv. Buckets	18
Gem Pans	4
Ice Box	1
Ladles	6
Lard Cans	4
Meat Grinder	1
Nutmeg Grater	1
Pot Chain	1
Pastry Brushes	6
Paring Knives	6
Pie Tins	36
Pails, Soup	10
Potato Masher	1
Poker	1
Range	1

KITCHEN CAR

Article	
Roast Pans	3 (Large)
Roast Pans	2 (Half Size)
Rolling Pin	1
Skimmers	3 Small
Stew Pans	2 Medium
Stew Pan	1 Large
Stock Boilers	2-10 Gal.
Stock Boilers	2-15 Gal.
Stock Boiler	1-20 Gal.
Spoons, Basting	6
Scales, Spring	6
Sieve, Flour	1
Tin Cups, Pts.	6
Tin Cups, Qts.	12
Wire Broiler	1
Wash Board	1
Wilson Steel	1
Wire Brush	1

MISCELLANEOUS

Article	
Clocks	2
Chairs	2
Hatchets	2
Hammers	2
Hand Saw	1
Lantern	1
Padlocks	4
Tobacco Cutter	1
Wrench	1

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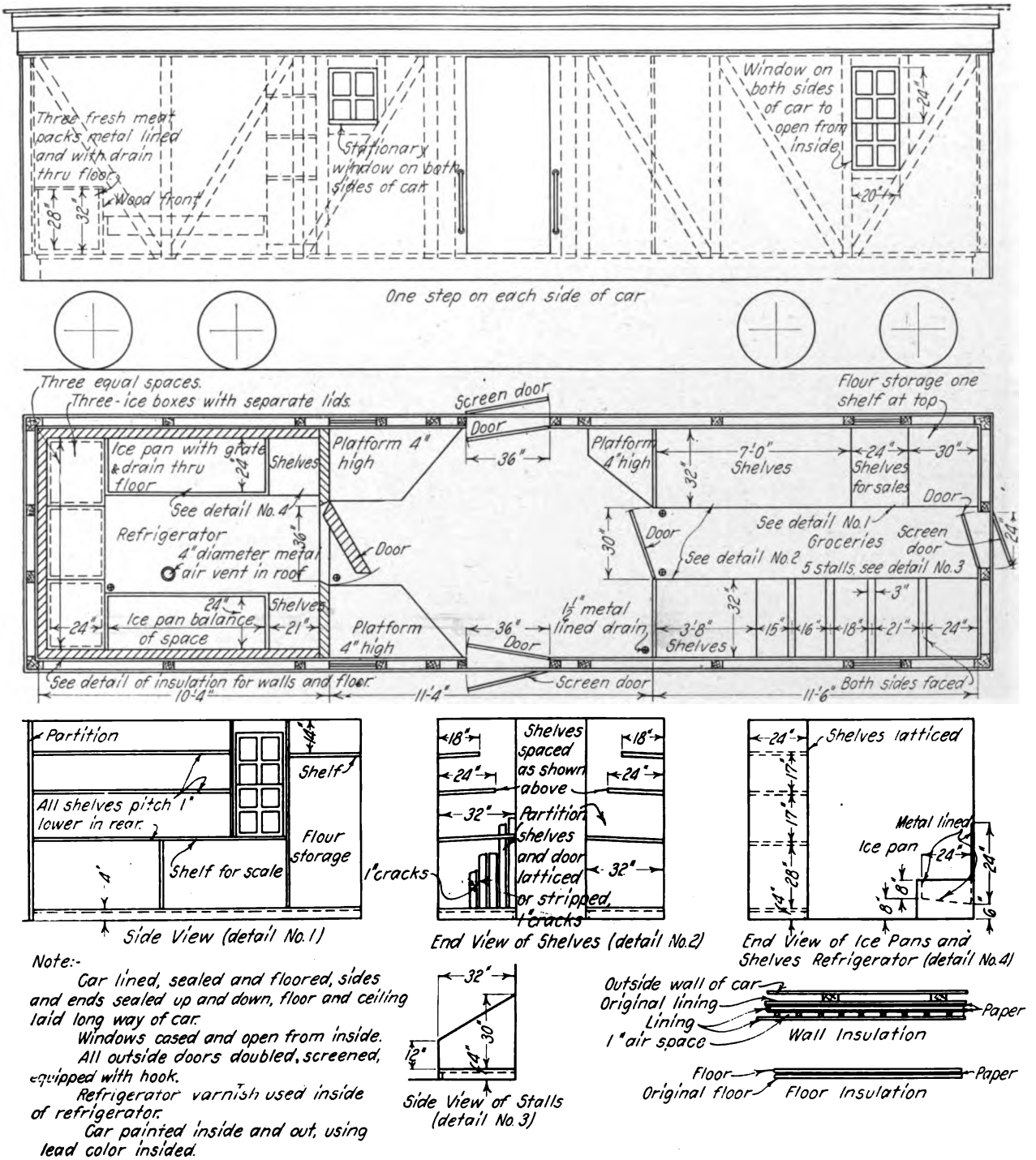

Standard Supply Car of the Chicago, Burlington & Quincy Boarding Train

fittings as possible are of metal the problems of sanitation and fumigation are much less difficult than with wood fitted box cars. An attractive set of boarding cars well maintained tends to reduce the labor turnover and by retaining the men, exerts a decided influence on the efficiency of their work and the economies which it is thus possible to effect. Thorough ventilation is a consideration which should be given the best attention in the design of cars to be used for habitation. It is rarely feasible to house less than eight laborers in a box car. The roofs of these cars are low and in warm weather the best of ventilation is necessary for the comfort of the men. Mere cooling is not enough and strong air currents are undesirable. There are many styles of good ventilators which can be economically installed with more advantage to efficiency of labor than is generally realized.

The accompanying list of equipment and cars is standard on the Chicago, Burlington & Quincy for 50-men boarding trains operated by J. J. Grier, contractor.

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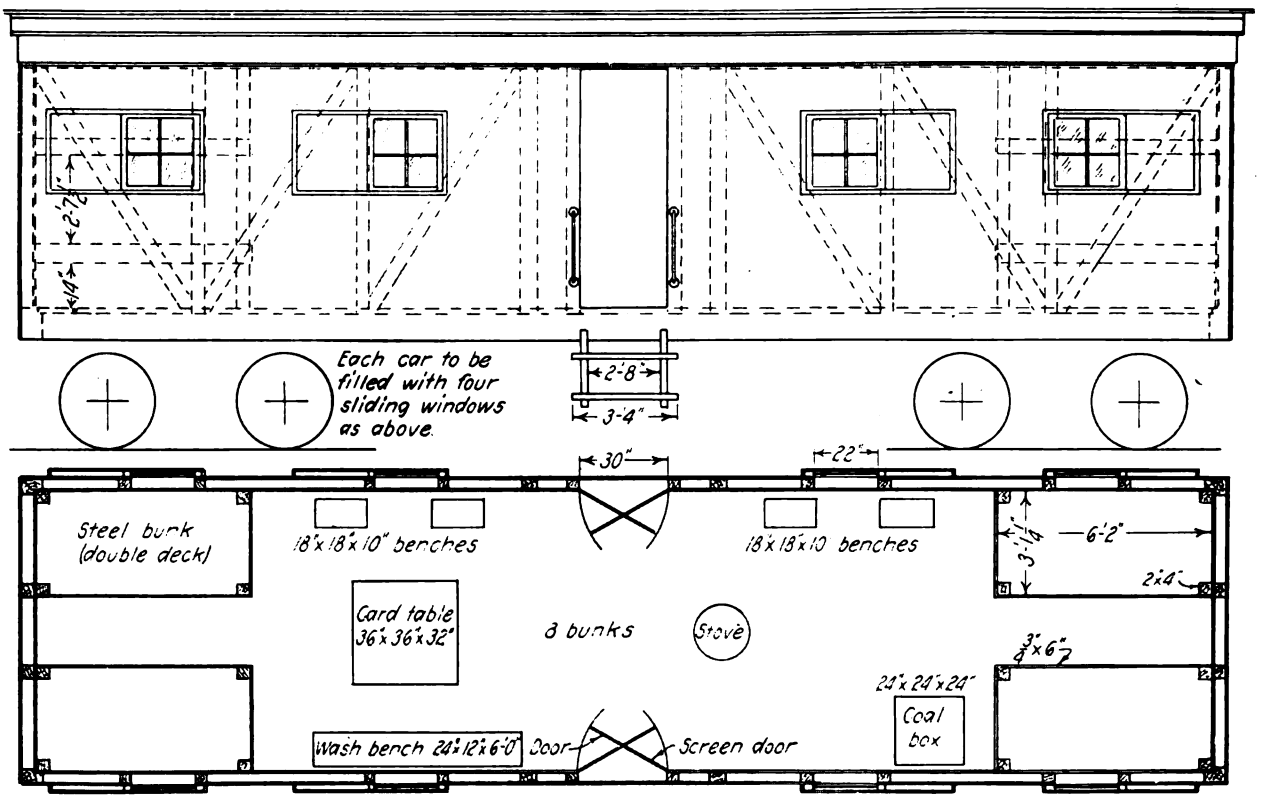


Standard Bunk Car, Chicago, Burlington & Quincy Boarding Train.

Camp Car Boarding Train on the Duluth, Missabe & Northern

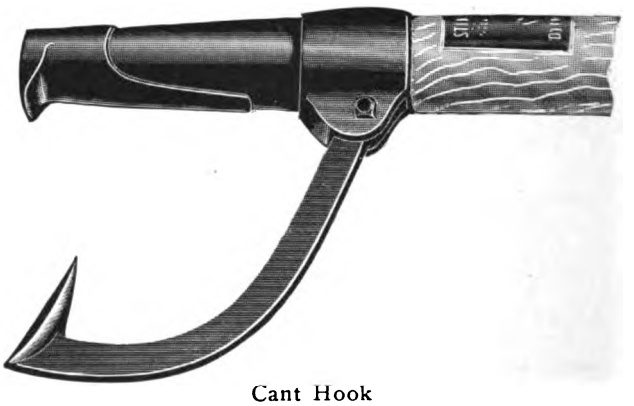
CAR EQUIPMENT FOR GANG OF 50 MEN

1 Foreman's Car
1 Commissary and Office Car
1 Kitchen Car
2 Dining Cars
6 Bunk Cars
1 Locomotive Water Tank
1 Store and Refrigerator Car
1 Tool Car

CANTHOOK. A tool for holding and rolling logs or heavy timbers.

It consists of a wooden lever or handle about 5 ft. long with a curved steel hook hinged in it near the butt for canting or turning over heavy logs or bridge timbers. The iron hook is rectangular in section, about 1 in. wide and ½ in. thick and curved to about an 8 in. radius, while the end is shod with a sharp spike which hooks into the timber when the wooden handle, placed over the top of the timber, is raised.

An iron clamp partly encircles the handle about 12 in. above its butt and is held in place by a bolt which also passes through the eye in the shank end of the hook allowing it to move freely in the same plane as the wooden handle.



Cant Hook

On the butt end of the handle a long beveled sided sharp spike called a peavie pike, is sometimes fastened, which prevents the wooden handle from slipping and also allows the tool to be used as a pinch bar. This type of canthook is commonly called a peavie.

CASTING. Any metal shape which has been formed by pouring the molten metal into a mold, which is subsequently removed from the finished piece.

Castings are made of steel as well as from the more ductible malleable iron. (See Pages 643 and 772).

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CEMENT. Any composition which is plastic at a certain degree of temperature or moisture but which at another degree is tenacious, being therefore adaptable to uniting separate parts of one material or pieces of materials of different kinds, as well as to making smooth and even surfaces.

Many compounds are included under this term, such as gums, glues, limes, mortars, etc., all of which, under certain conditions, change their consistency from liquid or slightly sticky to plastic or hard and stonelike, the hardening being known as "setting." Cement which sets under water is called hydraulic cement, this class including the three structural classes, (1) Portland cement, deriving its name from a resemblance to Portland stone, (2) natural cement, a powder made of an impure limestone, partly clay and sand burnt at a comparatively low temperature, only sufficient to separate the carbonic acid gas, and (3) Puzzolan cement, a finely ground mixture of slacked lime and basic blast furnace slag.

Portland cement is the structural binder which has come into such general use for concrete, the material which has so largely superseded stone masonry in the building trades. The use of concrete in combination with metal reinforcement has revolutionized masonry design and construction, broadening the field for permanent structures on a basis of economy formerly unknown, and to such an extent as to largely replace wood as a building material. See Cement, Portland. Also Concrete.

CEMENT (Natural). A cement made by burning and pulverizing impure limestone which contains a suitable percentage of clay or material rich in clay, the heat applied being only sufficient to rid the product of its carbonic acid gas. See Cement.

A. R. E. A. SPECIFICATIONS

Fineness. It shall leave by weight a residue of not more than 10 per cent on the No. 100, and 30 per cent on the No. 200 sieve.

Time of Setting. It shall not develop initial set in less than 10 minutes; and shall not develop hard set in less than 30 minutes, or in more than 3 hours.

Tensile Strength. The minimum requirements for tensile strength for briquettes 1 sq. in. cross section shall be as follows, and the cement shall show no retrogression in strength within the periods specified.

Age	Neat Cement	Strength
24 hours	in moist air	75 lb.
7 days	(1 day in moist air, 6 days in water)	150 lb.
28 days	(1 day in moist air, 27 days in water)	250 lb.
One part cement, three parts standard Ottawa sand.		
7 days	(1 day in moist air, 6 days in water)	50 lb.
28 days	(1 day in moist air, 27 days in water)	125 lb.

Constancy of Volume. Pats of neat cement about 3 in. in diameter, ½ in. thick at the center, tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(a) A pat is then kept in air at normal temperature.
(b) Another is kept in water maintained as near 70 deg. as practicable.

These pats are observed at intervals for at least 28 says, and to satisfactorily pass the tests, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

CEMENT, PORTLAND. A blue gray powder, made by mixing, burning and grinding clay and chalk or substances rich in those ingredients, and which hardens when wet.

As a binder for concrete it possesses superior strength and setting qualities when thoroughly mixed with the water, sand and stone or gravel in proper proportions, a common mixture being 1:2:5 of cement, sand and crushed stone or gravel with enough water to come to the surface of a vessel which has been previously filled with the dry materials.

In 1824 Joseph Aspdin, an Englishman, made Portland cement for the first time by burning a mixture of lime and clay to a clinker and then grinding the clinker to a powder. It was named "Portland" cement because of its resemblance in color to building stone from the Isle of Portland off the English coast.

About 1850 real progress in the manufacture of Portland cement began in England and Germany. In the United States natural cement was first made in 1818 and Portland cement in 1872, when Portland cement plants began operations at Copley, Pa., and at South Bend, Ind. Considerable difficulties arose in competing with imported cements and the American cement progress was slow until 1895, when the rotary kiln was developed. This was invented by F. Rauson in England in 1873, but was developed in this country and soon supplanted the old upright or bottle kiln.

The following table shows the development of the Portland cement industry in the United States from 1880 to 1919 inclusive:

Year	Portland Cement Bbls. Produced	Natural Cement Bbls. Produced	Foreign Cement Bbls. Imported
1880	42,000	2,030,000	187,000
1890	336,000	7,082,000	1,940,000
1895	990,000	7,741,000	2,997,000
1900	8,082,000	8,384,000	2,387,000
1905	35,247,000	4,473,000	897,000
1910	76,550,000	1,139,000	307,000
1915	85,521,000	751,000	42,000
1917	92,814,000	639,000	2,323
1918	70,915,508	432,966	305
1919	85,485,000	.....	.....

The manufacturing process consists of grinding to a fine powder the raw materials (usually a calcareous and an argillaceous material) and proportioning them according to previous chemical analyses and the burning of the mixture to a clinker in a kiln at a temperature around 2700 deg. F., the clinker, after seasoning a few days, being ground to a powder together with about 2½ per cent of gypsum to retard the rate of setting.

The percentages of various raw materials chiefly used in the manufacture of Portland cement in the United States in 1919 are as follows:

Calcareous Materials	Argillaceous Materials	Percent Total Cement Made
Limestone	Clay	51
Limestone	Cement Rock	31
Limestone	Blast Furnace Slag	14
Marl	Clay	4
Alkali Waste	Shale-slate	Foreign

Portland cement must pass certain rigid tests instituted as a result of study by a special committee representing the U. S. Government engineers, the American Society of Civil Engineers and the American Society for Testing Materials.

The chemical composition of American Portland cements usually fall within the following limits:

	Per cent		Per cent
Silica	19-25	Lime	60-64
Alumina	5-9	Magnesia	1-5
Ironoxide	2-4	Sulphur trioxide	1-2

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A. R. E. A. SPECIFICATIONS FOR PORTLAND CEMENT

General Conditions. All cement shall be inspected.

Cement may be inspected either at the place of manufacture or on the work.

In order to allow ample time for inspecting and testing, the cement should be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

Every facility shall be provided for by the contractor and a period of at least twelve days allowed for the inspection and necessary tests.

Cement shall be delivered in suitable packages, with the brand and name of the manufacturer plainly marked thereon.

A bag of cement shall contain 94 lb. net of cement. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

Cement failing to meet the 7-day requirements may be held awaiting the results of the 28-day tests before rejection.

All tests shall be made in accordance with the methods proposed by the committee on uniform tests of cement of the A. S. of C. E., presented to the society January 21, 1903, and amended January 20, 1904, and January 15, 1908, with all subsequent amendments thereto.

The acceptance or rejection shall be based on the following requirements:

This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent has been made subsequent to calcination.

Specific Gravity. The specific gravity of cement shall not be less than 3.10. Should the test of cement as received fall below this requirement, a second test may be made upon a sample ignited at a low red heat. The loss in weight of the ignited cement shall not exceed 4 per cent.

Fineness. It shall leave by weight a residue of not more than 8 per cent on the No. 100, and not more than 25 per cent on the No. 200 sieve.

Time of Setting. It shall not develop initial set in less than 30 minutes, and must develop hard set in not less than 1 hour, nor more than 10 hours.

Tensile Strength. The minimum requirements for tensile strength for briquettes 1 sq. in. in cross section shall be as follows, and the cement shall show no retrogression in strength within the periods specified:

Age	NEAT CEMENT	Strength
24 hours in moist air		175 lb.
7 days (1 day in moist air, 6 days in water)		500 lb.
28 days (1 day in moist air, 27 days in water)		600 lb.
	One Part Cement—Three Parts Standard Ottawa Sand	
7 days (1 day in moist air, 6 days in water)		200 lb.
28 days (1 day in moist air, 27 days in water)		275 lb.

Constancy of Volume. Pats of neat cement about 3 in. in diameter, ½ in. thick at the center and tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(b) Another pat is kept in water maintained as near 70 deg. F. as practicable, and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for 5 hours.

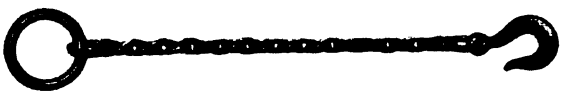
These pats, to satisfactorily pass the requirements, shall remain firm and hard, and show no signs of distortion, checking, cracking, or disintegrating.

Sulphuric Acid and Magnesia. The cement shall not contain more than 1.75 per cent of anhydrous sulphuric acid (SO_3), nor more than 4 per cent of magnesia (MgO).

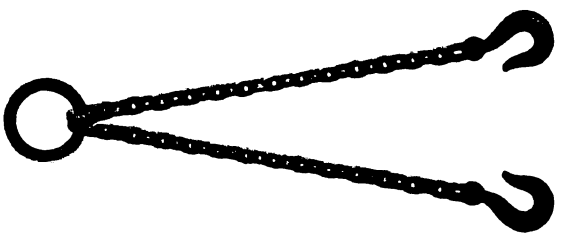
CHANNEL. A structural steel shape of the cross-sectional form of three adjacent sides of a parallelogram, of which the long side is the web, with two flanges, both of which are placed on one side of and at the opposite edges of the web. Channels are commonly used in fabricating members of railway structures, such as chords, columns, braces, etc.

CHAIN. A series of metal links or rings connected to form a line which is used in tension for much the same purposes as a rope or a cable, especially where durability and resistance to the action of heat, water, abrasion are required.

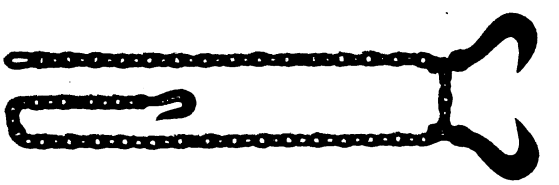
Chains are in general use for confining, restraining, supporting and transmitting mechanical power as in steam shovels, locomotive cranes, derricks, elevators, hoists, conveyors, pile drivers, snow plows, etc. They also form an important part of the equipment issued to bridge and building gangs, to steam fitters, plumbers, signal maintainers and wrecking gangs.



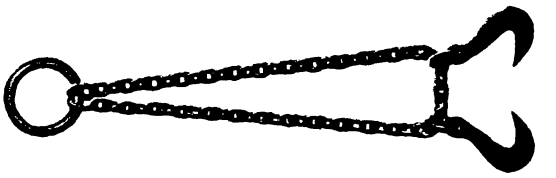
Single Pattern Sling Chain



Double Pattern Sling Chain



Single Pattern Derrick Chain



Double Pattern Sling Chain

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As to form, a chain is commonly made of links of identical shapes, dimensions and strength. One-piece oval welded links of round iron or steel which form the common or cable chain, as well as crane, sling and dredge chains, etc., are assembled with the adjacent ends of the bent bar which forms the second link meeting within the oval space enclosed by the first link, while the ends of the third link meet within the space enclosed by the second link and so on to the end of the chain, each intermediate link enclosing a space partly occupied by the two adjacent links, the ends of each link being welded in place by the fire welding or electric welding process.

A link is usually designated by its pitch or inside longest diameter and by the diameter of the rod from which it is made. Chains are classified according to the service proposed, the shape of the link and the character of the metal. Common or cable chain is known as proof coil chain, made in sizes of $\frac{3}{16}$ in. to 1¼ in. inclusive. B. B. coil chain is of higher quality and has shorter links, while BBB coil chain known as crane quality, is a short link chain of still greater strength. A coil chain is usually made of such length that it will fill the keg in which it is coiled for shipment. Crane and dredge chains are preferably made of a grade of iron especially selected for the service. Twist link chains are also used on many machines, each link being twisted 90 deg. so that when one end is laid flat the other end is seen edgewise.

Chains are tested to half their breaking strains, the safe-working load being about half the proof test. The service life of a chain, especially when used over sheaves, drums or wheels, can be lengthened by frequent periodical lubrication and annealing, as well as by cutting out worn portions if the wear is not uniform. A chain in daily severe use should be slacked and oiled weekly, while hoisting and sling chains should be annealed (heated red hot and allowed to cool slowly) and inspected at least once a year. All chain is subject to an initial stretch after manufacture when subjected to the test load. Special chains are those which are fitted with hooks, rings, pear-shaped links, swivel turnbuckles, etc., to connect them to bucket bales, hooks or rings of machines, as in various types of dredge, sling and crane chains.

Round hooks are made of bars three times the diameter of the chain, while square holes are of material twice the diameter of the chain. For example, a square grab hook for 1 in. chain is of 2 in. square iron, while a round hook for the same chain is made of 3 in. diam. iron. A ring should be made of material of twice the diameter of the material in the chain on which the ring is to be used, provided the inside diameter of the ring is not more than six times the diameter of the chain material. In case a larger ring is required it is made of proportionately heavier material of equal grade.

Wheel or block chains used to run over wheels or sheaves fitted with pockets as on chain hoists, are stretched prior to use so that the links fit into the indentations of the wheel. Conveyor chains, sometimes made of long welded one-piece links to fit over the teeth of the sprocket wheels, are similarly tested and the links must be free from twist to prevent them from running off the teeth of the sprocket while in service. Conveyor chains are also made of links with flat parallel bars joined by means of end cross pins, alternate link bars being spread to enclose ends of adjacent bars, each pin penetrating four bars. When used on sprockets such chains are made so that the alternate wide links engage adjacent sprocket teeth, while the closed links come between the teeth.

CHECK (Timber). A small shrinkage crack in the wood due to seasoning. The moisture frequently evaporates so rapidly from the stick that the cellular structure shrinks and cracks apart along lines of cleavage between fibers due to the variation of moisture content in the different parts of the timber such as the heart wood and sap wood. Checks are commonly radial from the central pith of the tree, and are sometimes remedied by driving an S or Z shaped steel strap edgewise into the end of the stick to arrest the cracking tendency. See Tie, Cross, (Track Section).

CLAM-SHELL. A grab bucket having a tray composed of two equal opposite scoops which spread to open on loose material and sink into the pile on account of the weight of the bucket when closing.

The clamshell is operated by means of blocks and lines, from the boom of the crane where the controlling mechanism is located. These buckets are made in capacities ranging from ½ cu. yd. to 6 cu. yd. or more. Buckets of 1 cu. yd. to 2 cu. yds. capacity are in general use for handling coal. A 2 yd. bucket is about 8 ft. high over all and usually of about the same closed width. The weights vary considerably, an ordinary 2 yd. bucket weighing 4000 lb. See Grab Bucket.

CLAMP. A gripping device usually of metal or wood, having two jaws, one of which is movable and can be closed on its mate by means of a screw, a spring, a wedge or the like; or both jaws may be movable and so connected that the weight of the object held between them developes the grip which holds it. See Vise.

CLASSIFICATION OF RAILWAYS. Railways have been divided by the A. R. E. A. as to main tracks, traffic and train speeds, into three classes as follows:

Class "A" includes all districts of a railway having more than one main track, or those districts of a railway having a single main track with a freight car mileage that equals or exceeds 150,000 per mile per year; or a passenger car mileage of 10,000 per mile per year with a maximum speed of passenger trains of 50 miles per hour.

Class "B" includes all districts of a railway having a single main track with a traffic that is less than the minimum prescribed for Class "A" and with a freight car mileage that equals or exceeds 50,000 per mile per year; or a passenger car mileage of 5,000 per mile per year; with a maximum speed of passenger trains of 40 miles per hour.

Class "C" includes all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

CONCRETE. A compact mass of broken stone or gravel or other suitable material assembled

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together with cement mortar and allowed to harden in place, usually in prepared pits or built-up forms, thus producing artificial stone work. (A. R. E. A.)

Mass concrete made of natural cement and subsequently of the stronger Portland cement was used for a number of years prior to the establishment of the present practice of combining the properties of the concrete with those of embedded steel reinforcement to resist stresses. The result of this practice is that concrete has become the most widely used of all masonry materials.

Ingredients

The ingredients of concrete are (1) crushed stone or gravel (or substitutes) commonly known as the coarse aggregate (2) silicious sand, known as the fine aggregate (3) Portland cement and (4) clean water. The stone or gravel is usually screened in order to separate the fine and coarse aggregates. Definite proportions have been established with a view to covering all portions of the surfaces of each particle of sand and stone, or gravel with adherent cement of which there shall be sufficient to fill all the spaces between the particles of aggregate, thus minimizing porosity. There must be enough small aggregate to form a slight excess of mortar to insure filling all the voids, as a little may be lost during delivery. The amount of water to be used has varied from the dry-mix of the days of the Manchester dam when the most energetic hand tamping was necessary to bring dampness to the surface, through an extreme wet-mix period of watery, weak concrete to the present time when just enough water is used to saturate the aggregates, hydrate the cement and render the mass quaking and workable without either being too stiff for spading to free the air from bubbles formed in the mass and to work the concrete thoroughly into all portions of the forms, nor so watery that the cement will be wasted by running out from the mass. The precise amount of water can only be determined by tests with samples of the materials being used, but when this has been determined for a day's run, the matter is fairly in the hands of the supervisor, if he has the proper plant and authority.

Mixing

Hand mixed concrete, although superseded on large work by machine mixed products, is still made on small or special work. The cement is first dumped dry on the sand which is then turned over with shovels, etc., until the whole pile assumes a cement color with no sand streaks. It is then shoveled outward from the pile to form a circular ridge and water is poured in the central hollow thus formed. Working from the outside the cement and sand is shoveled into the water and mixed with it without breaking the ridge to let free water escape. When the process is complete the mortar is in a pile where the sand was first dumped. It is then shoveled on top of successive layers of stones as they are spread from a pile until the whole batch is together, after which the entire batch is turned until all particles are covered with the wet mortar and ready to deposit in the forms.

Mixing Machines

Hand mixing is a slow process as compared with machine mixing, which may be done by means of either of two classes of machines, (1) continuous and (2) batch mixers. The continuous mixer may be a gravity machine or a power rotated container with a hopper for the cement, sand and stone and an inlet for water as well as a delivery spout for the freshly mixed concrete. The mixing barrel is commonly provided with blades, or some stirring device to agitate materials as they roll over in the mixing, the delivery aperture being opened and closed at will. This method is rapid and satisfactory when the feed, speed and delivery proceed in unison and in correct ratio of materials used. The batch mixer is so made that it receives a certain stated amount of each ingredient into which is automatically fed a measured amount of water after which the machine is rotated a certain time, usually 1½ minutes. When the batch has been delivered another is put in the mixer barrel and so on.

Concrete mixers are made in many styles, the rotators being conical, cubical, barrel shaped, etc. The mixer is usually combined with a gasoline engine or other power plant and frequently has a power loading device consisting of a hopper hinged or pivoted at the inlet of the rotator, and a hoist by means of which the materials, dumped into the rotator while it is resting on the ground, may be tilted into the rotator when the hopper is lifted to the upright position. Some mixers have water-measuring devices and automatic batch outlets. A large mixer may be an expensive machine for a small piece of work while a small mixer would be too slow for extensive work. Rugged, simple, well-maintained machines are essential, as the service is usually severe. Most engineers recognize the necessity for two sizes of mixers or more on maintenance work which includes station platforms, sidewalks and small house foundations, etc., as well as large bridge piers, arches, retaining walls and other extensive works.

Concrete Forms

Forms for concrete are the wood or metal molds into which the fresh material is poured and where it assumes the contours and sets in the desired shape of the structure. Wooden forms are set up by carpenters and sometimes are re-used several times, especially arch centerings. A considerable percentage of the form timber and lumber must, however, be re-worked at each project and even the most careful handling will not prevent a great deal of waste unless there is means at hand to rapidly resaw pieces, keeping the skilled labor busy constructing forms rather than hand working lumber to fit their needs. Portable resaw machines are economical in this connection. In many cases as in culverts where it is feasible to construct a section of work at a time, a collapsible sectional form may be used and re-used to advantage, two retaining wall forms being sometimes sufficient to afford a continuous supply when alternately moved or used. This method, however, is better adaptable to the use of the more permanent metal forms which may be greased to prevent the concrete from adhering to the inside surfaces. All manner of buildings, bridges, culverts, arches, retaining walls, etc., are erected by means of collapsible metal forms in suitable units, the forms being an essential part of

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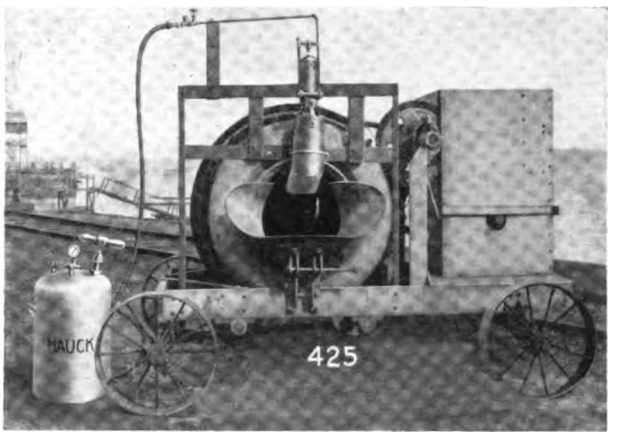
permanent equipment. They are made in half rounds, telescopic round shapes and adjustable square to rectangular box shapes for culverts, as well as in arch roof sections and braced straight wall sections, moving on trolleys for tunnel work and traveling wall forms for high retaining walls. Flanged and keyed column forms and collapsible arch bridge ribs are used as well as concrete pipe and block forms.

Forming is an item of importance in concrete work, its prospective re-use where possible being an



Concrete Heater
The Hauck Manufacturing Co.
(See Page 703)

incentive to the formulation of standard designs in such units as are desirable for structures and parts. Advantages of metal forms are that spading does not injure them, they do not warp or crack and being smooth offer little frictional resistance.

Reinforcement

Concrete reinforcement is made of steel bars variously shaped and fabricated. The chief shapes of bars are round, square, half-round, deformed and twisted. The bars are placed in the forms and wired together at splices as well as between twisted wires to hold them in place between the walls of the forms. A common method is to make a network of two series of parallel rods placed at right angles to each other and tied at the intersections. The sections of rods are made irregular and the rods are frequently bent with a view to securely fastening them in place in the concrete, although these precautions are commonly considered unnecessary. Collapsible column reinforcement is available in convenient units. It is a cylindrical cage of horizontal hoops tied between two or more upright rods which can be released to permit the parallel hoops to fall flat in an overlapping row. See Cement, Portland.

A. R. E. A. Specifications for Concrete, Plain and Reinforced

Materials.

Cement.

1. The cement shall meet the requirements of the A. R. E. A. specifications for portland cement. It shall be stored in a weather-tight structure with the floor raised not less than one foot from the ground in such a manner as to permit easy access for proper inspection and identification of each shipment. Cement that has hardened or partially set shall not be used.

Fine Aggregate.

2. (a) The fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry, a screen having holes ¼ in. in diameter. Not more than 25 per cent by weight shall pass a No. 50 sieve, and not more than 6 per cent a No. 100 sieve when screened dry, nor more than 10 per cent dry weight shall pass a No. 100 sieve when washed on the sieve with a stream of water. It shall be clean and free from soft particles, mica, lumps of clay, loam or organic matter.

(b) The fine aggregate shall be of such quality that mortar briquettes made of one part of portland cement and three parts of the fine aggregate by weight shall show a tensile strength, after an age of seven days, not less than the strength of briquettes of the same age, made of mortar of the same consistency in the proportion of one part of the same cement to three parts of standard Ottawa sand.

Coarse Aggregate.

3. The coarse aggregate shall consist of gravel or crushed stone, which, unless otherwise specified or called for on the plans, shall, for plain mass concrete, pass a screen having holes 2¼ in. in diameter, and for reinforced concrete a screen having holes 1¼ in. in diameter; and be retained on a screen having holes ¼ in. in diameter, and shall be graded in size from the smallest to the largest particles. It shall be clean, hard, durable and free from all deleterious matter; coarse aggregate containing dust, soft or elongated particles shall not be used.

Stone for Rubble or Cyclopean Concrete.

4. These stones shall be of good quality, clean, dense and hard, without seams and having sharp edges. They shall not be smaller than of a size known as one man stone.

Slag.

5. Provided the contract specifically permits the use of crushed slag as a coarse aggregate, it shall be air cooled, blast furnace slag, conforming to all the requirements for coarse aggregate specified in paragraph 3. The crushed slag shall weigh not less than 70 lb. per cu. ft., and shall be obtained only from such banks as have the approval of the engineer. All slag used shall have seasoned in the bank for a period not less than one year, unless in the opinion of the engineer a shorter period is sufficient.

Water.

6. The water shall be free from oil, acid and injurious amounts of vegetable matter, alkalies or other salts.

Steel Reinforcement.

7. (a) All structural steel shapes used for reinforcing shall conform to the requirements of the A. R. E. A. specifications for steel railroad bridges.

(b) All steel rods or bars used for reinforcing shall conform to the requirements of the A. R. E. A. specifications for billet-steel concrete reinforcement bars.

Proportioning.

Unit of Measure.

8. The unit of measure shall be the cubic foot. Ninety-four lb. (sack or ¼ barrel) of cement shall be assumed as 1 cu. ft.

Proportions.

9. (a) The proportions of the materials shall be in accordance with the plans, or detailed specifications, or schedule governing the work. When not otherwise specified, the proportions by volume shall be as follows: (See 8, 10.)

Class.	*Use.*	*Cement.*	*Fine Aggregate.*	*Coarse Aggregate.*
A	Reinforced concrete—Concrete deposited under water	1	2	4
B	Mass concrete in forms	1	2½	5
C	Foundation	1	3	6

(b) Rubble or cyclopean concrete, when permitted by the contract, shall be either Class "B" or Class "C" concrete, having embedded in it large stones.

(c) For any given class of concrete, the relative proportion of cement to fine aggregate shall not be modified. The relative proportion of fine to coarse aggregate shall be modified, if necessary, during the progress

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of the work, so as to obtain the maximum density. (See 9a.)

Measuring Proportions.

10. The various ingredients, including the water, shall be measured separately, and the methods of measurement shall be such as to invariably secure the proper proportions. The fine and coarse aggregate shall be measured loosely as thrown into the measuring receptacle. (See 8, 9a.)

Consistency.

11. The quantity of water used in mixing shall be the least amount that will produce a plastic or workable mixture which can be worked into the forms and around the reinforcement. Under no circumstances shall the consistency of the concrete be such as to permit a separation of the coarse aggregate from the mortar in handling. An excess of water will not be permitted, as it seriously affects the strength of the concrete, and any batch containing such an excess will be rejected.

Premixed Aggregate.

12. (a) Provided the contract specifically permits, premixed aggregate may be used instead of separate fine and coarse aggregates. Frequent tests shall be made to determine the relative proportions of fine and coarse aggregates, and if these proportions are unsatisfactory to the Engineer, or so irregular as to make it impracticable to secure a properly proportioned concrete, he may reject the material, or require that it be screened and used as separate fine and coarse aggregates.

(b) The proportion of the cement to the fine aggregate shall at no time be less than that specified for the classes of concrete where separate aggregates are used. (See 9a.)

Forms

Materials.

13. (a) The forms shall be of wood or metal, and shall conform to the shape, lines and dimensions of the concrete as called for on the plans. Form lumber used against the concrete shall be dressed on one side and both edges, to a uniform thickness and width, and shall be sound and free of loose knots.

(b) For all exposed edges, corners or other projections of the concrete, suitable moldings or bevels shall be placed in the angles of the forms to round or bevel the edges of the concrete.

Workmanship.

14. (a) The forms shall be well built, substantial and unyielding, and made sufficiently tight to prevent leakage of mortar and voids in the concrete. They shall be properly braced or tied together by rods, bolts or wires. Metal braces or ties shall be so arranged that when the forms are removed, no metal shall be within one inch of the face of the finished work.

(b) The face forms shall be securely fastened to the studding or uprights in horizontal lines.

(c) Any irregularities in the forms which may mar the exposed surface of the concrete shall be removed or filled.

Inspection.

15. Where necessary, temporary openings shall be provided at the base of the forms to facilitate cleaning and inspection directly before placing concrete. (See 23b.)

Oiling.

16. The inside of the forms shall generally be coated with raw paraffin or other non-staining mineral oil; or thoroughly wet with water, except in freezing weather. (See 23b.)

Removal of Forms.

17. The forms shall not be removed until authorized by the engineer.

Reinforcement

Placing Reinforcement.

18. Reinforcing steel shall be cleaned of all mill and rust scales before being placed in the forms. All reinforcement shall be placed in its proper position as required by the plans and securely wired or fastened in place, well in advance of the concreting, and shall be inspected and approved by the engineer before any concrete is deposited. (See 23b.)

Splicing Reinforcement.

19. Wherever it is necessary to splice the reinforcement otherwise than as shown on the plans, the character of the splice shall be decided by the engineer on the basis of safe bond stress and the stress in the reinforcement at the point of splice. Splices shall not be made at points of maximum stress.

Mixing

Machine Mixing.

20. (a) All concrete shall be mixed by machine (except when under special conditions the engineer permits otherwise), in a batch mixer of an approved type, equipped with suitable charging hopper, water storage and a water measuring device which can be locked.

(b) The ingredients of the concrete shall be mixed to the required consistency and the mixing continued not less than one and one-half minutes after all the materials are in the mixer, and before any part of the batch is discharged. The mixer shall be completely emptied before receiving materials for the succeeding batch. The volume of the mixed material used per batch shall not exceed the manufacturers' rated capacity of the drum. (See 11.)

Hand Mixing.

21. When it is permitted to mix by hand, the mixing shall be done on a watertight platform of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. The batches shall not exceed ½ cu. yd. each. The materials shall be mixed dry until the mixture is of a uniform color, the required amount of water added, and the mixing continued until the batch is of a uniform consistency and character throughout. Hand mixing will not be permitted for concrete deposited under water. (See 11.)

Retempering.

22. The retempering of mortar or concrete which has partially hardened; that is, remixing with or without additional materials or water, will not be permitted.

Depositing

General.

23. (a) Before beginning a run of concrete, all hardened concrete or foreign materials shall be completely removed from the inner surfaces of all conveying equipment.

(b) Before depositing any concrete, all debris shall be removed from the space to be occupied by the concrete, all steel reinforcing shall be secured in its proper location, all forms shall be thoroughly wetted except in freezing weather unless they have been previously oiled, and all form work and steel reinforcing shall be inspected and approved by the engineer. (See 15, 16 and 18.)

Handling.

24. Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible, and by methods of transporting which shall prevent the separation of the ingredients. The concrete shall be deposited directly into the forms as nearly as possible in its final position so as to avoid rehandling. The piling up of concrete material in the forms in such manner as to permit the escape of mortar from the coarse aggregate will not be permitted. Under no circumstances shall concrete that has partially set be deposited in the work. (See 22.)

Compacting.

25. During and after depositing, the concrete shall be compacted by means of a shovel or other suitable tool moved up and down continuously in the concrete until it has all settled into place and water has flushed to the surface. The concrete shall be thoroughly worked around all reinforcing material so as to completely surround and embed the same.

Cold Weather.

26. During cold weather, the concrete at the time it is mixed and deposited in the work shall have a temperature not lower than 50 deg. F., and suitable means shall be provided to maintain this temperature for at least 72 hours thereafter, and until the concrete has thoroughly set. The methods of heating materials and protecting the concrete shall be approved by the engineer. The use of any salt or chemical to prevent freezing will not be permitted.

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Depositing on or Against Set Concrete.

27. Before depositing new concrete on or against concrete which has set, the forms shall be retightened against the face of the latter, the surface of the set concrete shall be roughened and thoroughly cleaned of foreign matter and laitance, and saturated with water. The new concrete placed in contact with set or partially set concrete shall contain an excess of mortar to insure bond. To insure this excess of mortar at the juncture of the set and newly deposited concrete on vertical or inclined surfaces, the cleaned and drenched surface of the set concrete shall first be slushed with a coating of mortar, not less than one inch thick, composed of one part cement to two parts fine aggregate, against which the new concrete shall be deposited before this mortar has had time to attain its initial set.

Rubble or Cyclopean Concrete.

28. After each layer of concrete is placed, and before it has taken its initial set, the stones are to be thoroughly bedded in the soft concrete. No stone shall be placed nearer than 1 ft. to any finished surface; nor nearer than 6 in. to any adjacent stone. After the stones are in place another layer of concrete shall be placed sufficient to cover the stones to a depth of at least 6 in.

When stratified stones are used, they shall be laid upon their natural bed. (See 4, 9b.)

Depositing Concrete Under Water.

General.

29. Concrete shall not be deposited in water without the written consent of the engineer. A written statement of the methods and plans of equipment to be used shall be submitted to and approved by the engineer before the work is started. (See 9a, 11, 21.)

Cofferdams.

30. Cofferdams shall be sufficiently tight to prevent any current through the space in which the concrete is to be deposited. Pumping will not be permitted while the concrete is being deposited, nor until it has fully set.

Method.

31. The concrete shall be deposited by such method as will prevent the washing of the cement from the mixture. In no case shall the concrete be allowed to fall through the water.

Tremie.

32. The tremie, where used, shall be about 14 in. or 16 in. in diameter, and made flanged and put together with gaskets. The initial filling of the tremie shall be done in such manner as not to permit the concrete to drop through the water. It shall be kept filled at all times, and the discharge end raised a few inches at a time as the filling progresses. The greatest care shall be used to prevent the charge being lost in moving the tremie about on the surface of the deposited concrete. In case the charge is lost, the tremie must be withdrawn and refilled.

Drop Bottom Bucket.

33. (a) The bucket, where used, shall be of such a type that it cannot be dumped until it rests on the surface upon which the concrete is to be deposited. The frame shall extend below the closed bottom doors so they may open freely downward and outward when tripped. The ends of the bucket shall extend without openings to the bottom of the frame. The top of the bucket shall be open.

(b) The bucket shall be completely filled, and slowly lowered to avoid unnecessary back wash. When discharged the bucket shall be withdrawn slowly until clear of the concrete.

Bagging.

34. The bags, when used, shall be of jute or other coarse cloth. They shall be about two-thirds filled with concrete, and shall be carefully placed by hand in a header and stretcher system so the whole mass is interlocked.

Continuous Operation.

35. Where possible, the concrete shall be deposited continuously from the time the work is started until it is brought above water level or to the finished surface. The work shall be carried on with sufficient rapidity to insure bonding of the successive layers. The surface of the deposited concrete shall be kept as nearly level as possible.

Laitance.

36. Great care shall be exercised to disturb the concrete as little as possible while it is being deposited, to avoid the formation of laitance. On completing a section of concrete, the laitance shall be entirely removed after the concrete has thoroughly set and before the work is resumed.

Joints

General.

37. (a) Instructions given on the plans, in the detailed specifications or schedule governing the work as to location and construction of joints, shall be strictly followed.

(b) When the structures or portions of the structures are designed to be monolithic, they shall be cast integrally, except as hereinafter modified. (See 38a, b, c, d.)

Construction Joints.

38. (a) When necessary to provide construction joints not indicated, or specified, such joints shall be located and formed so as to least impair the strength and appearance of the structure. Where conditions require, the joints shall be reinforced as directed by the engineer, in order to secure the necessary bond strength.

(b) Horizontal construction joints shall be prepared at the time the work is interrupted by thoroughly roughening the surface and providing keys by embedding stones which project above the surface, or mortises by embedding timbers which shall be removed before the work of placing concrete is resumed.

(c) At all horizontal or vertical construction joints, the surface of the previously deposited concrete shall always be roughened and cleaned of all laitance and foreign material before depositing new concrete. (See 27.)

(d) Where girders, beams and slabs are designed to be monolithic with walls and columns, they shall not be cast until four hours after the completion of the walls or columns in order to permit of shrinkage or settlement. In case the columns are structural steel, encased in concrete or concrete columns having flaring heads, the lapse of time to allow for shrinkage or settlement need not be observed. (See 37b.)

Watertight Joints.

39. When it is not possible to finish a complete section in one continuous operation, and a watertight joint is required, sheet lead or other metal, not less than six inches wide, and extending the full length of the joint, shall be embedded equally in the two deposits of concrete.

Sliding Joints.

40. Where sliding joints are to be provided, the seat shall be finished with a smooth trowel surface and shall not have the superimposed concrete placed upon it until the previously deposited concrete has thoroughly set. Unless otherwise indicated on the plans, or specified, two thicknesses of building paper shall be placed over the bearing before the superimposed concrete is deposited, in order to make a defined sliding joint.

Expansion Joints.

41. (a) At all expansion joints, the break in the bond between the two sections shall be complete, and shall be insured by the application of petroleum oil, hot coal tar pitch, tarred felt or similar material over the entire joint surface of the first deposited concrete.

(b) No reinforcement shall extend across an expansion joint.

(c) Triangular shaped grooves shall be formed in the exposed surface of the concrete at all expansion joints in walls or abutments.

(d) Where expansion joints are formed between two distinct concrete members, and said joint is exposed, it shall be filled with an elastic joint filler of approved quality.

Surfacing and Finishing

General.

42. Except where a special surface or finish is required, the surfacing and finishing shall be done in accordance with the requirements specified for a spaded surface. (See 43a, b, c.)

Spaded Surface.

43. (a) The coarse aggregate shall be carefully worked back from the forms into the mass of the con-

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crete with spades, fine stone forks, bars or other suitable tools, so as to bring a surface of mortar against the form. Care shall be taken to remove all air pockets and to prevent voids in the surface.

(b) Except where otherwise directed by the engineer, face forms shall be removed as soon as the setting of the concrete will permit (See 17.)

(c) After the removal of the forms, any holes or voids in the surface of the concrete shall be filled with a mortar made of the same proportions of sand and cement as those of the concrete and rubbed smooth and even with the surface with a wooden float. A trowel shall not be used for this purpose. (See 42.)

Top Surfaces.

44. (a) Top surfaces shall generally be "struck" with a straight edge or "floated" after the coarse aggregates have been forced below the surface.

(b) Where "sidewalk finish" is called for on the plans, it shall be made by the spreading of a 1:2 mortar at least ¾ in. thick, and floating this to a smooth surface. This finishing coat shall be put on before the concrete has taken its initial set. For a walk, the surface shall be slightly roughened with a special tool or by sweeping with a coarse broom.

Wetting Surfaces.

45. The surfaces of concrete exposed to premature drying shall be kept thoroughly and constantly wetted for a period of at least 3 days. For wearing surfaces, this period shall be at least 10 days.

Special Finishes

General.

46. (a) In special work where detailed instructions are given on the plan, or in the specifications, as to conveying, depositing, or finishing concrete, the same shall be strictly followed; where a special finish is called for, the same shall be in accordance with the following paragraphs that apply to the finish called for.

(b) The forms shall be made of lumber dressed to a uniform thickness and width, or dressed and matched to a uniform thickness and width, or lumber lined with metal, or metal carefully built to exact dimensions and shape, with close level joints, smooth inside surfaces and sufficiently braced and tied together to be unyielding. The inside surfaces shall be washed just before the concrete is placed. Where the smoothest surface practicable with all wooden forms is desired, the inside surface shall be coated with light paraffin oil, boiled linseed oil, or other approved material.

(c) The whole extent of a surface to be finished shall be built in one continuous operation. Where a continuous operation is not possible, the seam or joint between the concrete placed first and that placed later shall be made watertight, with sheet lead or other metal, embedded equally in the two deposits of concrete or by some other approved method.

(d) The same brand of cement shall be used throughout the whole of any surface or structure.

(e) Where margins, patterns or different finish from the remainder of the surface are required, the forms shall be removed at the proper time to permit these to be laid off and finished in the best manner for the method specified.

(f) All work shall be finished free from streaks, discolorations or other imperfections that impair the appearance or life of the finish.

Rubbed Finish—Carborundum or Cement Bricks.

47. (a) The coarse aggregate shall be carefully worked back from the forms into the mass of the concrete with spades, fine stone forks, or other suitable tools, so as to bring a surface of mortar against the form. Care shall be taken to remove all air pockets and to prevent voids in the surface.

(b) The forms shall be carefully removed from the surface to be finished as early as practicable, all joint marks, projections and inequalities chipped off, and all voids filled with a mortar made of the same proportions of cement and sand as those of the concrete.

(c) These surfaces shall then be thoroughly wet with water, and while wet, rubbed to a smooth uniform finish, with a brick made of one part Portland cement and two parts or two and one-half parts sand, or with a No. 3 Carborundum brick followed by a No. 30 or with a No. 24 carborundum brick, as may be necessary to obtain the desired degree of smoothness.

(d) No mortar or cement shall be applied except to fill distinct voids in the surface. Uneven places shall be smoothed by rubbing down and not by plastering. The surface shall be kept moist and protected from rapid drying for not less than three days. (See 46a, b, c, d, e, f.)

Rubbed Finish—Wooden Floats.

48. (a) The coarse aggregate shall be carefully worked back from the forms into the mass of the concrete with spades, fine stone forks, or other suitable tools, so as to bring a surface of mortar against the form. Especial care shall be taken to remove air pockets and to prevent voids in the surface.

(b) The forms shall be carefully removed from the surface to be finished while the concrete is green, all joint marks, projections and inequalities chipped off, and all voids filled with a mortar made of the same proportions of cement and sand as those of the concrete.

(c) The surfaces shall then be rubbed with soft wood floats, and kept well flushed with water during the rubbing. When the desired finish is obtained, the whole surface shall be thoroughly washed with water.

(d) No mortar or cement shall be applied except to fill distinct holes or cavities. Uneven places shall be smoothed by rubbing down and not by plastering. The surface shall be kept moist and protected from rapid drying for not less than three (3) days. (See 46a, b, c, d, e, f.)

Faced Surfaces.

49. (a) The outside layer of the surface to be finished shall be composed of one part cement and three parts graded aggregate mixed to a stiff mortar. The aggregate shall be crushed to pass a sieve of ⅜ in. mesh and be retained on a No. 100 sieve. The cement and the aggregate shall each be measured carefully and accurately for each batch and all batches shall be gaged with the same amount of water and carefully mixed in the same manner and for the same length of time, in order to obtain uniform surfaces.

(b) For vertical surfaces the above surface mixture shall be placed against the forms by skilled workmen (using metal slip plates, where practicable) in a layer not less than one inch thick, as the concrete is deposited, in order that the surface mixture shall form a part of the mass of the concrete. Care shall be taken to remove air pockets and to prevent voids in the surface. For horizontal surfaces, the surface mixture shall be placed as the concrete is deposited and before the concrete has set, and, where possible, troweled or floated to an even surface. (See 46a, b, c, d, e, f.)

Unfaced Surfaces.

50. (a) The surface concrete shall be of the same mixture as specified for the body of the structure. The cement and the aggregate shall be measured carefully and accurately for each batch and all batches shall be gaged with the same amount of water, and carefully mixed in the same manner, and for the same length of time, in order to obtain uniform surfaces.

(b) The concrete shall be spaded vertically against the forms only as much as will remove air pockets and prevent voids, care being taken not to force the coarse aggregate away from the form. (See 46a, b, c, d, e, f.)

Washed or Scrubbed Finish.

51. As soon as the concrete has hardened sufficiently, but while it is still green, the forms shall be carefully removed from the surface to be finished, and all voids filled with the surface mixture. The surface shall then be scrubbed with water and brushes of stiff fiber, or of wire, until the aggregate is sufficiently exposed and projects slightly, but not enough to injure its adhesion in the mass. The whole surface shall then be washed with water until thoroughly clean. If necessary, in order to remove the film of cement from the surface of the exposed aggregate or to better bring out the color, the surface shall be washed with a solution of one part commercial hydrochloric acid and two and one-half parts water, applied with brushes of stiff vegetable fiber. All traces of the acid shall be immediately and completely removed by washing with water. After the final

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washing, the surface shall be kept moist and protected from rapid drying for not less than three days. (See 46a, b, c, d, e, f.)

Acid Treated Finish.

52. (a) After the forms are removed all voids shall be filled with the surface mixture. The surface to be finished shall then be washed with commercial hydrochloric or nitric acid, diluted with water according to the age and hardness of the concrete. The strength of the solution shall be determined by trial on the work, and shall only be such that the bond of the cement will be readily broken to the required depth. The solution shall be applied with stiff vegetable fiber brushes, and the surface scrubbed until the aggregate is exposed to the desired amount.

(b) As soon as the desired surface is obtained, all traces of the acid shall be quickly and completely washed off with water to prevent its further action, and the permanent discoloration of the surface. (See 46a, b, c, d, e, f.)

Note.—For concrete that is but a few days old a dilution of one part acid to six parts water may be sufficient. For concrete two weeks old, a dilution of only two or three parts may be necessary.

Sand Blast Finish.

53. After the forms are removed, all voids shall be filled with the surface mixture, and left to harden as long as possible. All joint marks and projections shall be chipped off. The outside mortar shall then be cut away with a sand-blast, using a hard sand with angular grains. The nozzle shall not be larger than ⅛ inch diameter, and shall be held close to the surface. Care shall be taken to cut all the surface to a uniform depth. The work shall preferably be done between 10 and 14 days after the concrete is placed. (See 46a, b, c, d, e, f.)

Tooled Finish.

54. (a) The proportions of cement and fine aggregate shall be such as to produce a mortar of a density or hardness as nearly equal to that of the coarse aggregate as possible.

(b) After the forms are removed, all voids shall be filled with the surface mixture and left to harden as long as possible. After the concrete has set, and become hard, the surface to be finished shall be dressed (with a bush hammer of three to six cuts per inch, a crandall, a toothed pick, a pneumatic or an electric or other desired tool) to a uniform depth and finish. Care shall be taken to make all margins and patterns straight and true. (See 46a, b, c, d, e, f.)

CONCRETE FORM. A temporary mold or section of a mold in which concrete reinforcement is secured in place and in which fresh concrete is poured, embedding the reinforcement and spreading to the shape of the inside contours of the form which is not removed until the concrete is properly set, which may be from 14 days to 21 days according to conditions and the uses for which the concrete structure is designed. Forms were formerly made of wood, but are now largely made of iron and steel, advantages of the latter being durability, minimized friction, adaptability to artificial heatings for winter work, and readily removed after the concrete has set without marring or injuring the structure. See Concrete. Also Concrete Reinforcement.

CONCRETE (Reinforced). Concrete in which steel or other metal is embedded in such a manner that both concrete and metal act in unison to resist stresses.

The added resistance of steel reinforcement has made possible decided reductions in the mass of concrete structures and concentration of loads on foundations of less area than was possible in all concrete construction. It has likewise reduced the cost of concrete masonry structures and broadened the field for this type of building. See Concrete. Also Concrete Reinforcement.

CONCRETE REINFORCEMENT. Steel rods of various cross sections and of convenient lengths for placing in concrete forms to be embedded in the concrete when it is poured into place.

These rods are frequently made of strips of scrap rails reheated and sawed to sections and of the required areas. Reinforcing steel is made usually in the form of rods of various cross sectional shapes. They are obtainable in any convenient lengths and are readily spliced and bent. The heavier sections sometimes require heating and machine bending which is accomplished better in the shop than in the field. See Concrete.

Specifications for Billet-Steel Concrete Reinforcement Bars

Material Covered.

1. (a) These specifications cover two classes of billet-steel concrete reinforcement bars, namely: plain and deformed.

(b) Plain and deformed bars are of three grades, namely: structural-steel, intermediate and hard.

(c) Twisted bars will not be accepted under these specifications.

Basis of Purchase.

2. The structural-steel grade shall be used unless otherwise specified.

(I) Manufacture

Process.

3. (a) The steel shall be made by the open-hearth process.

(b) The bars shall be rolled from new billets. No rerolled material will be accepted.

(II) Chemical Properties and Tests

Chemical Composition.

4. The steel shall conform to the following requirement as to chemical composition:

Phosphorus.....not over .05 per cent.

Ladle Analyses.

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 4.

Check Analyses.

6. Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel. The phosphorus content thus determined shall not exceed that specified in Section 4 by more than 25 per cent.

(III) Physical Properties and Tests

Tension Tests.

7. (a) The bars shall conform to the following requirements as to tensile properties:

TENSILE PROPERTIES

Properties Considered	Plain Bars			Deformed Bars		
	Structural Steel Grade	Intermediate Grade	Hard Grade	Structural Steel Grade	Intermediate Grade	Hard Grade
Tensile strength lb. per sq. in.	55,000 to 70,000	70,000 to 85,000	80,000 min.	55,000 to 70,000	70,000 to 85,000	80,000 min.
Yield point, min., lb. per sq. in.	33,000	40,000	50,000	33,000	40,000	50,000
Elongation in 8-in. min. per cent.	1,400,000 a	1,300,000 a	1,200,000 a	1,250,000 a	1,125,000 a	1,000,000 a
	Tens. Str.	Tens Str.	Tens. Str.	Tens. Str.	Tens Str.	Tens. Str.

a See section 8.

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(b) The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation.

8. (a) For plain and deformed bars over ¾ in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 7 (a) shall be made for each increase of ⅛ in. in thickness or diameter above ¾ in.

(b) For plain and deformed bars under 7/16 in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 7 (a) shall be made for each decrease of 1/16 in. in thickness or diameter below 7/16 in.

Bend Tests.

9. The test specimen shall bend cold around a pin without cracking on the outside of the bent portion, as follows:

BEND-TEST REQUIREMENTS

Thickness of Diameter of Bar	Plain Bars			Deformed Bars		
	Structural Steel Grade	Intermediate Grade	Hard Grade	Structural Steel Grade	Intermediate Grade	Hard Grade
Under ¾ in...	180 deg. d=t	180 deg. d=2t	180 deg. d=3t	180 deg. d=t	180 deg. d=3t	180 deg. d=4t
¾ in. or over..	180 deg. d=t	90 deg. d=2t	90 deg. d=3t	180 deg. d=2t	90 deg d=3t	90 deg. d=4t

Explanatory Note: d= the diameter of pin about which the specimen is bent.
t= the thickness or diameter of the specimen.

Test Specimens.

10. Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled.

Number of Tests.

11. (a) One tension and one bend test shall be made from each melt, except that if material from one melt differs ⅜ in. or more in thickness or diameter, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (a), and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(IV) Permissible Variations in Weight

Permissible Variations.

12. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

(V) Finish

Finish.

13. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

(VI) Inspection and Rejection

Inspection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

16. Samples tested in accordance with Section 6, which represent rejected bars, shall be preserved for two weeks, from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

CONVERTER. A steel pear-shaped shell lined with suitable fire brick, and mounted at the middle on trunnions so that it can be tilted at various angles, to be filled or emptied of metal, used in the Bessemer process of making steel. See Steel.

CONVEYOR. A mechanical contrivance for carrying materials.

Conveyors are made in many forms to suit the materials carried and the conditions under which they are to be moved. If the material is loose, such as coal or crushed stone, provision is made to carry it in pockets or scoops, on a moving endless belt with edges inclined toward the center. If the material is in large units not easily injured, such as cakes of ice or logs, the conveyor may be a chain belt with hooks or stops at intervals. Where the span is long and over inaccessible country or across streams, a cableway with a traveling tandem-wheeled carriage may be employed, the load being suspended beneath the carriage on cables. Where the loads are to be carried down a grade, the force of gravity may be utilized to move the loads over a conveyor formed of a series of horizontal parallel rollers mounted between side frames resting on trestles of the desired heights. When these rollers are too narrow for a portion of the loads, wheels of diameters greater than the rollers are mounted at the ends of the axles to carry the wide loads above the rollers. Other conveyors are inclined tracks on which small cars with flanged wheels are raised and dumped to discharge loads into cars below by means of a power cable or there may be two such conveyors operated reciprocally, the empty car going down partly counterweighting the full car on the way up. Still another type is a steam pipe through which a jet of steam forces loose material.

The last two conveyors are used to clear ashes from locomotive ash pits. The others are employed in a variety of ways. Gravity rollers are used for conveying building materials, such as lumber, ties, timbers, concrete blocks, bags of cement, etc.

Locomotive sand, ashes, coal, gravel, stone, etc., have frequently to be loaded on cars at isolated stations where such intermittent service does not justify establishing power plants and stationary machinery. Portable conveyors are usually more easily transported and more economical to operate in such cases than any rail equipment such as a steam shovel or crane as no track room or switching delays are involved. The economical conveyors of locomotive coal at unimportant stations where the amounts are small, is a problem never satisfactorily solved until the light portable conveyor was made available.

The transfer of freight from bad order cars, etc., is commonly effected by hand, when a portable conveyor would save car, days and labor. This work is frequently delegated to the nearest section or track gang as being the nearest available labor and also the most inexpensive. The employment of a portable conveyor at transfer stations for such emergency work will usually permit all the gang except one man to resume track work, at the same time ex-

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pediting the transfer of material and reducing the delays to cars.

Conveyors used in the crushing and washing of stone and gravel for ballast are sometimes of the gravity type, the materials being usually elevated to drop into the crusher and thence down through the washing chutes to the screens which separate it into the various sizes desired, gravity chutes being employed to further convey the selected material to the cars or bins.

The conveying of concrete by gravity involves the construction of a concrete chute or chutes and where the material to be placed is near or above the surface of the ground a tower is erected to obtain the necessary fall to all parts of the structure. A concrete tower is a temporary vertical elevator shaft of rough lumber and without siding. The concrete is elevated in a bucket by means of a cable, passing over a block at the top, operated usually by a gasoline engine or other portable power machine.

The bucket is tripped at the top of the conveyor shaft to discharge its contents into sharply inclined movable pipe or trough sometimes called a tremie which conveys the mass to its place in the forms. The depositing of concrete under still water is also sometimes accomplished by this method, a galvanized pipe with a bell end of metal or leather being used. By this method the material may be placed in the forms without dropping it through the water any appreciable distance, thus avoiding the tendency of the mass to separate.

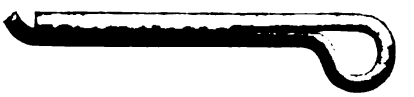
COPPER. A metal distinguished by its peculiar dull reddish color and ductility.

It is widely distributed and has been known and used from ancient times, the name being derived from Cyprium or Cyprus, the island from which the Romans obtained their best copper. The metal occurs in the native state as well as in various oxidized and sulphureted combinations and mixtures. It is almost nine times as heavy as water (Sp. gr. 8.838 for native copper); it is more malleable and ductile than any of the commonly used metals excepting gold and silver, at the same time being next to iron and steel in toughness. In the United States, copper is mined chiefly along the south shore of Lake Superior, in Arizona and in Montana.

In the Lake Superior district which supplies a large percentage of the world's production of the metal, copper occurs in regular fissure veins as well as in a volcanic conglomerate, both varieties yielding native copper. Masses of pure metal are found in the fissure veins or lodes, usually in the superficial portions and in small quantities. However the Lake region is also famous for great bodies of mass copper, one of which weighed some 300 tons, while many masses of less weight are frequently obtained. Owing to the ductility of the metal it is commonly more difficult to mine in the mass than to stamp from the ore bearing rock. Only in the Lake Superior region and in the less important Corocoro mines of Bolivia is copper mined exclusively in its native state. That which is mined in the western states is called electrolytic from the process employed to obtain the metal from the combinations in which it is found. The most abundant of the combinations is the well known yellow ore or copper pyrites, containing copper, iron and sulphur. Gold and silver are sometimes found in paying quantities in copper bearing mines, as in Arizona. The estimated annual world production of copper is about 900,000 tons of which the mines of the United States yield some 600,000 tons.

The metal has many uses, not only as copper but as a constituent of various alloys, such as brass, bronze, alloy steel, etc. It was formerly much sought as a sheathing metal before the use of pure iron and galvanized metals for that purpose. The electric conductivity of copper is a characteristic which renders it valuable for current-carrying wire, plates, etc. Copper wire is extensively used in telegraph and telephone lines, in solenoids and in many devices of the signal and electrical fields. Its resistance to oxidation makes it valuable also for roof flashings, gutters and down pipes, while it forms a constituent of some alloys used in structural steel, in bearings for wheels, machine bushings, turntable centers, etc. (See page 652.)

COTTER. A self-fastening pin consisting essentially of two parallel strips of metal which, when united, form one pin, but which, when the ends are forced apart, prevent the pin from being withdrawn. The cotter is commonly used as a fastening of bolts or other metal parts, notably in frogs and crossings, motor cars and pumping machinery.



Self-Spreading Cotter Pin

COTTER BOLT. See Cotter.

COUNTERWEIGHT. A weight used for the purpose of balancing or partly balancing a heavy movable portion of a mechanism, as a coaling plant elevator, a lift bridge span, a locomotive water tank spout, etc. Sometimes two movable parts are employed as counterweights for each other, as an empty cable car, raised to the top of an incline by a descending loaded car attached to the opposite end of the cable.

CRITICAL TEMPERATURE (Steel). The temperature to which it is necessary to heat steel to cause the thorough combination of elements, which produces the finest grained metal.

D

DEAD MAN. A buried timber, log or beam designed as an anchorage to which a guy wire or cable is fastened to support the weight of a structure, as a wood or steel column, a derrick, a mast, etc.

DEFORMED BAR. A steel bar, the section of which is mechanically distorted by being passed hot between rolls having indentations or projections which press the uniform bar into irregular sections with a view to increasing the resistance to the slipping of the bar through the concrete when used as reinforcement in concrete structures. Bars are variously deformed, some being crooked, others having projections at intervals, such as ridges of metal, while others are square section rods twisted into spirals, or alternately stamped into high and low rectangular sections.

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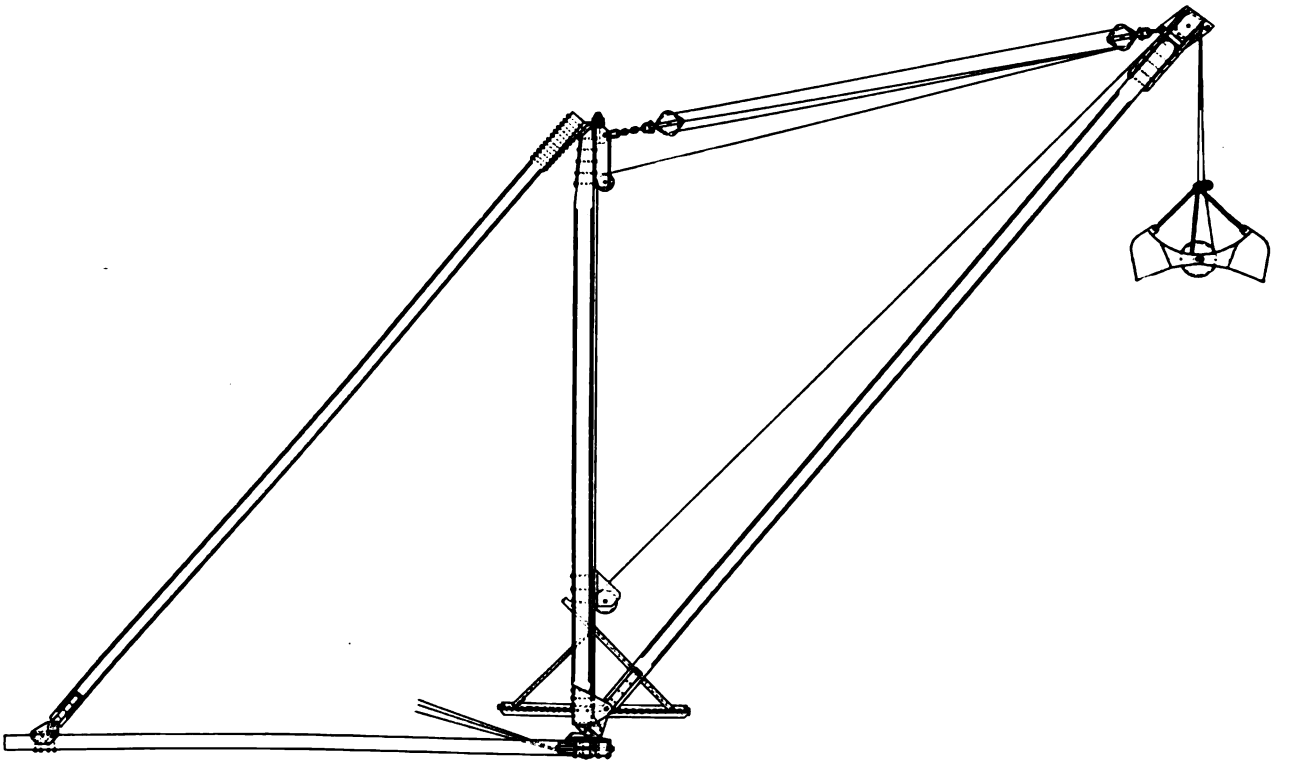
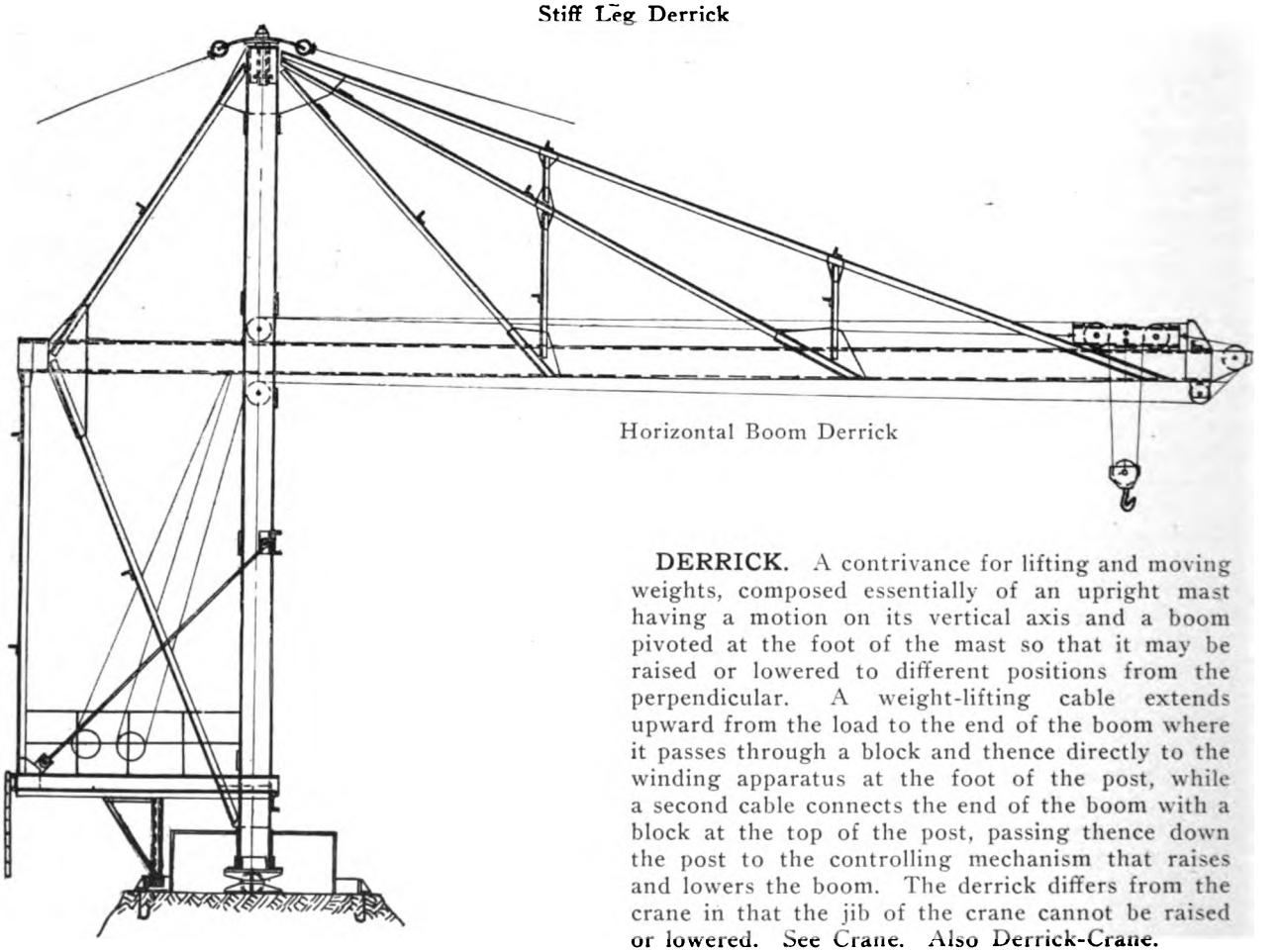


Stiff Leg Derrick



Horizontal Boom Derrick

DERRICK. A contrivance for lifting and moving weights, composed essentially of an upright mast having a motion on its vertical axis and a boom pivoted at the foot of the mast so that it may be raised or lowered to different positions from the perpendicular. A weight-lifting cable extends upward from the load to the end of the boom where it passes through a block and thence directly to the winding apparatus at the foot of the post, while a second cable connects the end of the boom with a block at the top of the post, passing thence down the post to the controlling mechanism that raises and lowers the boom. The derrick differs from the crane in that the jib of the crane cannot be raised or lowered. See Crane. Also Derrick-Crane.

DERRICK-CRANE. A crane with a mast held upright by fixed stays extending from its top to

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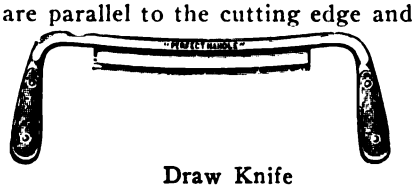
Derrick Truck Car
The Maintenance Equipment Co.
(See Page 739)

the rear, which limit the radial movements of the boom. See Crane. Also Derrick.

DOWEL. A pin, usually of circular section, designed to fit tightly into corresponding holes in abutting pieces of a structure to join and hold them in their proper relative positions. A dowel is of the same section throughout, and may extend into or through the members which it joins. If it extends through, it ends flush with the exterior surface of the member. Steel dowels are sometimes used to help hold adjacent parts of rail turnout and crossing frogs, etc. Wooden dowels are sometimes used in floors, or they may be driven into a masonry wall to hold nails, screws, etc., which fasten wooden members to the wall.

DRAW KNIFE. A carpenter's cutting tool for trimming and shaving timber.

It consists of a straight, bevel-edged steel blade on the ends of which are placed wood gripping handles which are parallel to the cutting edge and allow the



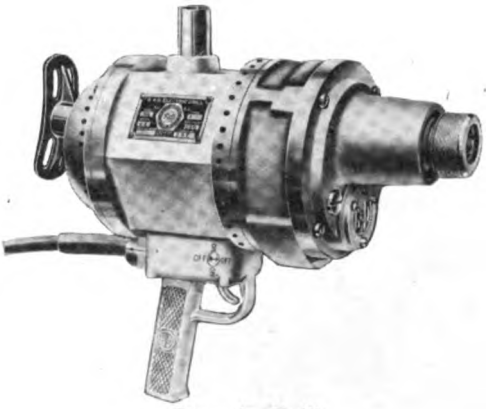
Draw Knife

tool to be drawn forward towards the operator. The cutting blade has a shoulder which tapers to a sharp wedge, the top side of which is beveled to a cutting edge. The bottom side of the tool is laid flat on the timber and acts as a guide or working surface.

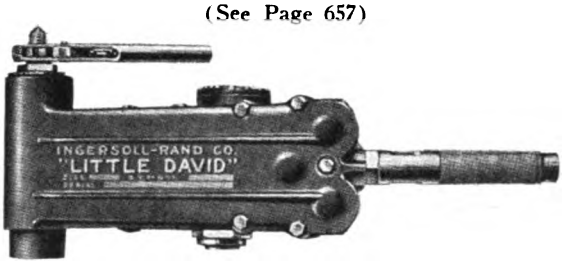
DRIER (Paint). A mixture of lead, cobalt or manganese products compounded with linseed oil and a thinner of volatile mineral spirits and turpentine. The mixture is commonly known as "combined drier and thinner" and is used to mix with thick paints to obtain the proper body for spreading and drying. See Paint.

DRILL. Any tool or machine used for boring holes in metal, stone or other hard substance; specifically a steel cutting tool, sometimes a straight steel bar driven with a sledge, but usually a bit fixed to a drill stock or a drilling machine. The

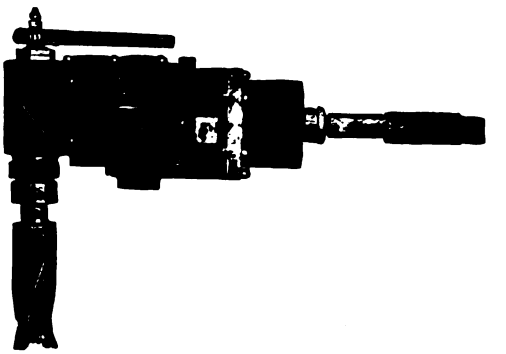
Little Giant Screw Spike Driver
The Chicago Pneumatic Tool Co.
(See Page 667)



Electric Drill
Black & Decker
(See Page 657)



Little David Close Quarter Drill
The Ingersoll-Rand Co.



Thor Close Quarter Piston Air Drill
The Independent Pneumatic Tool Co.
(See Page 714)

principal uses of drills include well drilling, making holes for blasting rock and boring through metal, notably in the fabrication of steel structures such as bridges, in the making of frogs, switches and crossings out of track rails, and in the drilling of rails in track for joint bars and for rail bonds.

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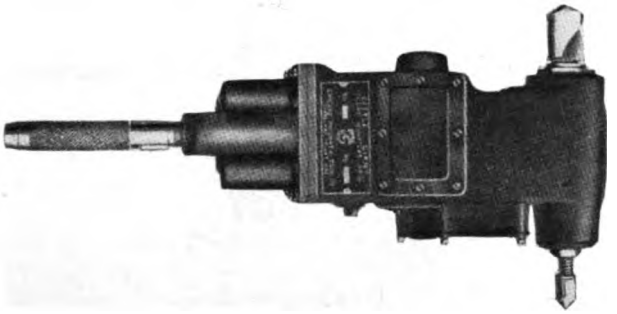
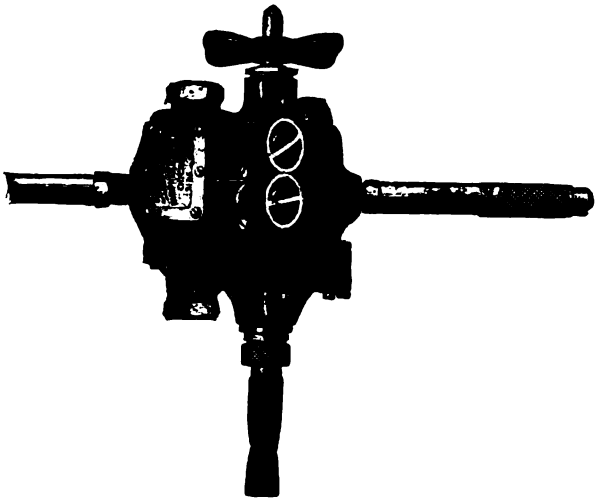
Drills may be classified as hand tools, portable power machines and shop machines. The simplest form of drill is a straight, blunt-shanked steel bar

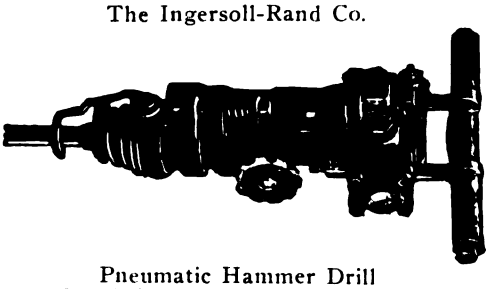


Little Giant Close Quarter Drill
The Chicago Pneumatic Tool Co.
(See Page 666)



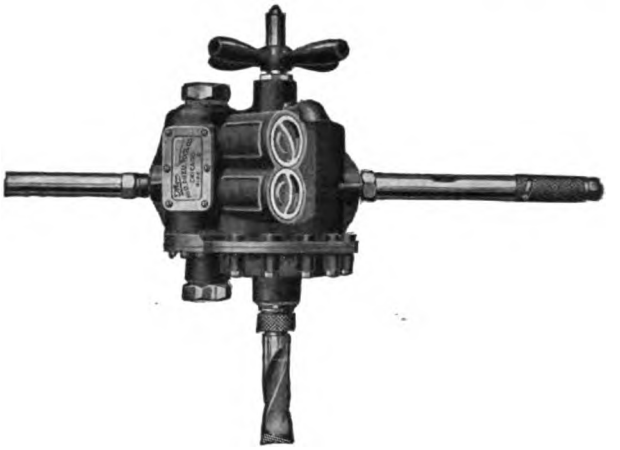
Thor Piston Air Drill
The Independent Pneumatic Tool Co.
(See Page 714)

Reversible Little David Drill
The Ingersoll-Rand Co.

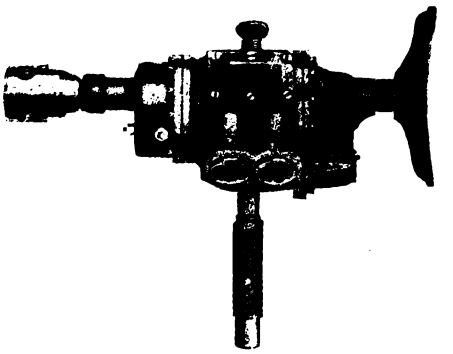


Pneumatic Hammer Drill
The Chicago Pneumatic Tool Co.
(See Page 667)

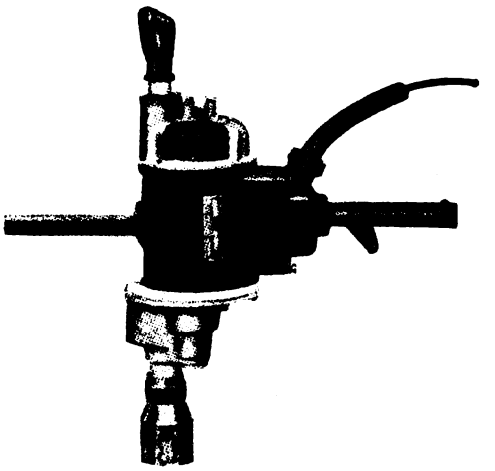
widened and flattened on opposite sides toward the working point to an angular cutting edge and designed to be rotated by hand between blows from a sledge on the shank end, this repeated cross-chiseling on the same spot tending to pulverize the rock and form a round hole, while the wide cutting edge provides side room in which to turn the tool without binding. From this primitive form the many rock and metal drilling machines have been developed, most of them operating by blows delivered in



Thor Pneumatic Drill
The Independent Pneumatic Tool Co.
(See Page 714)



Little Giant Drill
The Chicago Pneumatic Tool Co.
(See Page 666)



Little Giant Electric Drill
The Chicago Pneumatic Tool Co.
(See Page 666)

a line with the axis of the bit, but some kinds rotated on the boring principle to pulverize the material, to turn up shavings, or to cut out a circular core which rises inside the hollow drill bit.

When a drill hole is designed for permanent use,

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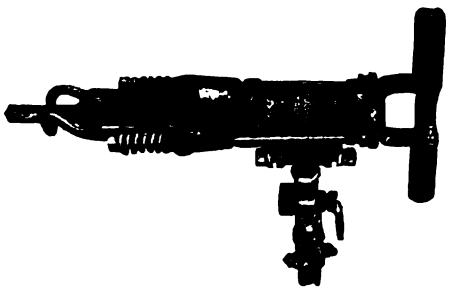
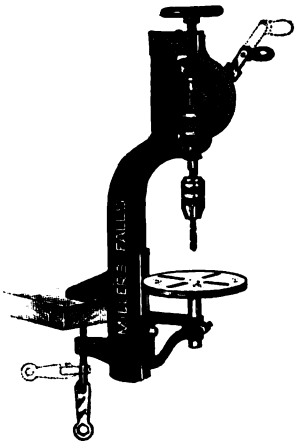
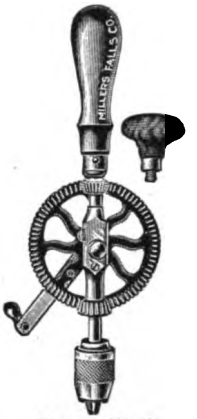


Rotator Hammer Drill
The Sullivan Machinery Co.



Bench Drill Press
The Millers Falls Co.



Hand Drill
The Millers Falls Co.

as for a well, a pipe lining called a casing is usually driven down as the drilling progresses and left in the ground to prevent earth, sand, etc., from clogging the hole.

The ordinary rock drill, used for comparatively shallow holes for blasting, etc., is a small and readily portable machine frequently used in the construction of rock excavations and tunnels. It is operated commonly by steam or compressed air or sometimes by electricity.

A common type is a steel drive head supported at the apex of a metal tripod with telescoping legs. The essential working parts are a cylinder with valve and piston and a feed screw in a metal case. The power is supplied to the cylinder by steam or compressed air, while the drill bit, attached to the end of the piston, rotates automatically on the back stroke. As the hole is deepened the drill is lowered by means of the feed screw. A smaller hand guide type of pneumatic rock drill in common use is identical with the pneumatic hammer with the exception of the drill-bit, which is fitted to the piston. The plain hand drill and hammer are now seldom used for rock drilling, having been superseded by the machines described above.

DRILL (Pneumatic). Any compressed-air driven tool used for drilling, reaming and boring in metal or other hard substance; commonly consisting of a two-piece steel casting containing a cylinder and gear case with a feed screw and drill-bit spindle extending vertically down through the center of the machine. Two opposite, horizontal, tubular steel handles provide balance for the drill, one containing the throttle valve and air hose connection while the other is used as a receptacle for lubricating oil. The feed screw, resting on the top of the spindle which holds the drill-bit is threaded to raise or lower the spindle by rotating a casting fastened to its shank. The drills made of special high speed steel are preferably reversible and are commonly designed to bore holes up to 3 in. in diameter.

Sullivan Hyspeed Rock Drill
The Sullivan Machinery Co.

DRILL PRESS. A bench tool for drilling holes, consisting of a movable work table and an iron frame in which a vertical revolving spindle is mounted to carry the drill-bit. This type of drill is adaptable to use in railway maintenance of way shops though some types are portable and supplied with bench clamps. The tool is operated by revolving the gear handle and at the same time feeding the pressure screw and chuck holding the bit into the metal by means of the top hand wheel.

DRILL (Rock). Any device designed for making holes in rock. The term is commonly limited to the portable machine tools operated by steam, compressed air or electric power to prepare holes for blasting excavations in rock such as railway cuttings, tunnels, etc. See Drill.

DRILL (Rotary Hand). A holding device for a drill-bit; specifically a hand-operated drilling machine which, when equipped with a drill-bit and pressed by hand or breast against the work, bores or drills holes. A hand drill commonly consists of a metal frame with a chuck or socket and spindle on the lower end and a hand or a breast plate press on the upper end. The device is operated by means of geared wheels on the side of the frame, connected to a pinion on the end of the chuck spindle. By turning a handle on the side gear wheel and pressing in the hand-hold or breast plate the drill-bit is forced into the work. Auxiliary chain attachments are sometimes used with breast drills to hold the bit against the work while the operator may press against the tool and turn handles on opposite sides of the gear wheel. This type of device consists of a metal cross yoke through which a central automatic feed screw and chuck spindle pass. This tool is commonly used to drill holes in wood

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or steel, such as rivet holes in steel track pans, bridge and building members, etc.

DRILL (Twist). A steel boring tool similar to a wood boring bit, the spiralled portion usually 3 in. or more in length and ending in a wide-lipped, double-beveled point, while the straight shank is shaped to fit in a brace or chuck for operation by hand, or by power, as in a pneumatic drill. Twist drills and especially their contact portions are commonly made of high-speed steel. See Drill. Also Drill Bit, Track.

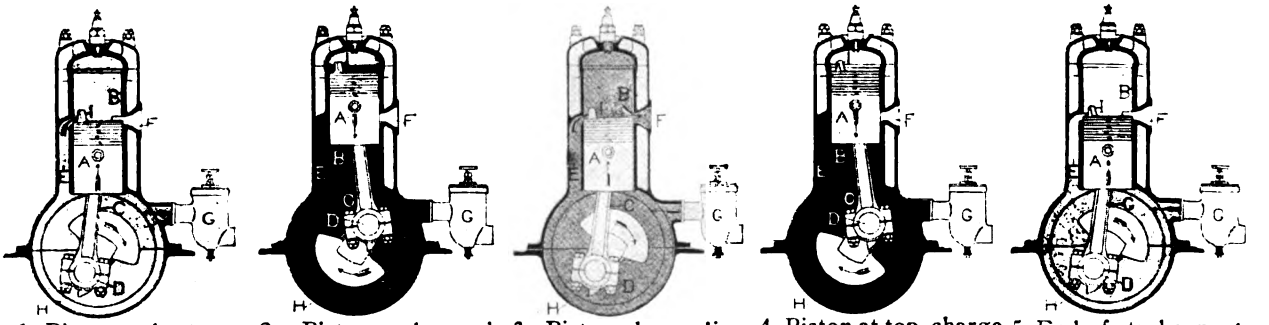
DYNAMITE. An explosive consisting of a mixture of nitroglycerine and an absorbent, sometimes sawdust used to diminish the sensitiveness of the nitroglycerine.

Dynamite is made in various strengths which are known by the percentages of the contents. It will burn quietly without exploding and usually will not explode when dropped. It is exploded with certainty with a detonator. See Explosive.

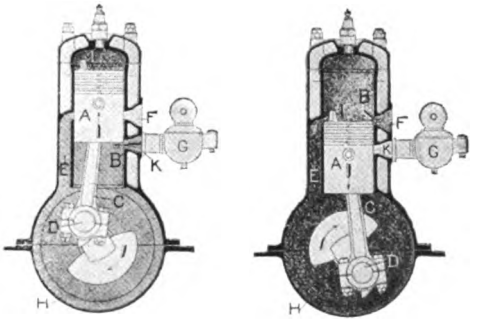
E

ENGINE (Gas). An internal combustion engine using vaporized fuel such as is derived from gasoline or light petroleum hydrocarbons. This type of engine, commonly used to drive such equipment as pumping apparatus, etc., consists usually of the cylinder and the necessary apparatus for directing the vaporized fuel to the combustion chamber of the cylinder, a crank shaft and two heavy steel fly-wheels secured on a horizontal steel frame. A piston working inside the cylinder is connected to the crank shaft, which imparts a reciprocating motion to it through a connecting rod. A steel shaft connected to the crank shaft and fastened to the front end of the engine frame operates the exhaust apparatus. The size of the engine depends on the horse power to be developed. See Engine, Internal Combustion.

Five Stages in Two Cycle Engine Operation



1. Piston at bottom, ports open
2. Piston advanced, fuel drawn in
3. Piston descending, fuel compressed
4. Piston at top, charge ignited
5. End of stroke, ports open, gas renewed



Three Port Engine Operation

1. Piston advancing, fuel entering from 3rd port, K
2. Piston at bottom, compressed charge entering cylinder

ENGINE (Internal Combustion). A heat engine which develops its power through the combustion of a mixture of some form of combustible gas or liquid hydrocarbons and their derivatives with air. The combustion of the mixture in the cylinder evolves great heat, dilates the gases and so creates a pressure which is applied to the piston. In this field of power generation, two distinct principles are involved, (1) internal combustion, (2) internal explosion.

Diesel engines operate on the internal combustion principle, injecting liquid fuel minutely atomized by air under high pressure, into combustion chambers containing nothing but pure air, so compressed that its temperature is far above that of the burning point of the fuel which at once ignites, complete but gradual combustion following.

Internal explosion engines, on the other hand, mix the carburant and air before or during compression, depending on some outside source of heat, as an electric spark, to ignite the explosive charge at the proper time while under compression. The gas or atomized fuel is introduced into the cylinders and mixed with air, the heat generated by compression completing the gasification. Internal explosion engines are designed to perform either two or four-stroke cycles per power stroke and are commonly called 2-cycle and 4-cycle engines.

The two-cycle cylinder may have two or three ports. In the operation of a two-cycle, two-port engine, the exhaust and inlet ports close as the piston ascends within the cylinder, drawing the explosive mixture through the carburetor and inlet valve into the crank case. As the piston descends the explosive mixture is compressed within the crank case until the piston reaches its lowest position, passing below and opening an inlet passageway through which the compressed charge in the crank case escapes from the crank case into the cylinder. As the piston again ascends, closing this inlet and exhaust ports, the charge within the cylinder above the piston is compressed and a new charge is drawn into the crank case below at the same time. When the piston reaches the top of the stroke, the charge is ignited and the exploded gases drive the piston down, permitting expansion, delivery of power and the compression of the new charge within the crank case. At the end of the power stroke both the inlet and exhaust openings are uncovered, permitting

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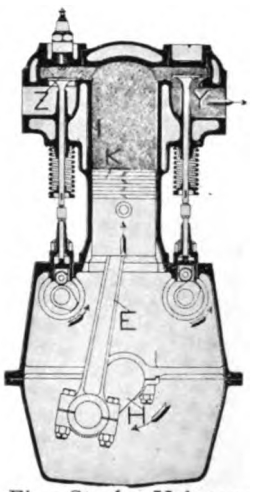
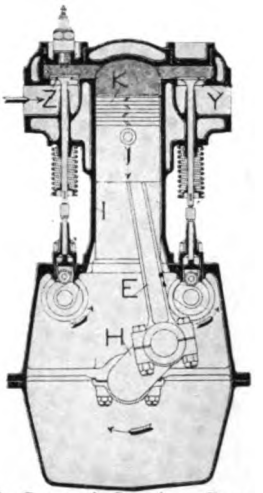
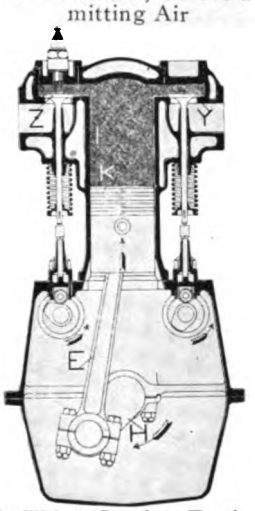
the burned gases to escape through the exhaust port while at the same time a fresh charge from the crank case enters the cylinder through the inlet passage where it strikes a deflector and is directed towards the top of the cylinder. Cylinder compression and crank case depression again take place as the piston ascends and covers the inlet and exhaust opening, the cycle of operation being continuously repeated from this point on, the rapid inrush of the new charge at atmospheric temperature tending to prevent the cylinder from heating.



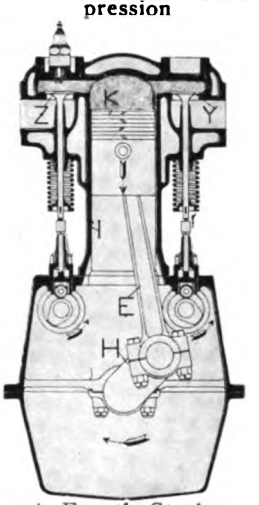
1. First Stroke, Valves admitting Air



2. Second Stroke, Compression



3. Third Stroke, Explosion



4. Fourth Stroke, Exhaust

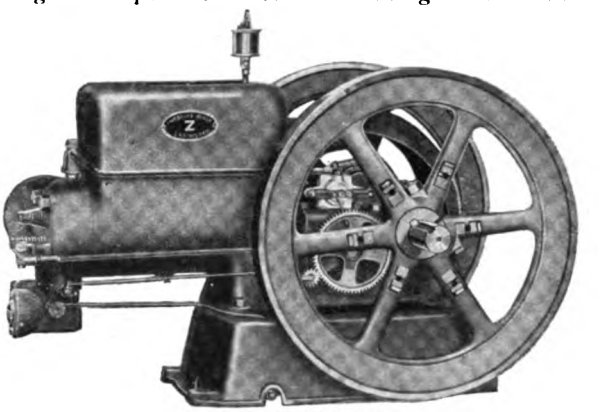
Single-cylinder, two-cycle engines of the three-port type have the advantage of creating an increased vacuum within the crank case; in all other respects the cycle of operation within the cylinder and crank case is the same as in the two-port engine.

The four-cycle engine, unlike the two-cycle type, is equipped with valves in the cylinder head through which the admission and exhaust of gases to and from the cylinder take place. As the piston descends in the cylinder the inlet valve opens, allowing air to pass through the carburetor where it is mixed with the fuel, follows the piston and fills the cylinder. At the end of the first stroke the inlet and exhaust valves close and compression begins and continues until the end of the second stroke. At the beginning of the third stroke the explosive mixture in the cylinder is ignited and the force of the exploding gas drives the piston forward, permitting expansion and the delivery of power. At the end of the third stroke, the exhaust valve is opened and the burned gas escapes as the piston ascends during the fourth stroke.

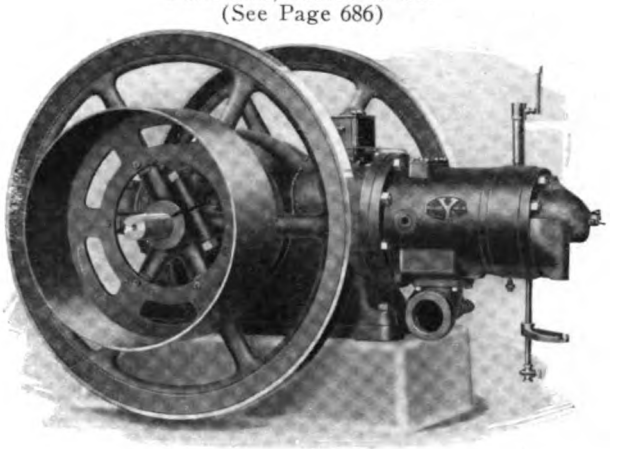
Text and cuts from Tide Water Oil Co. booklet.

The fundamental difference between the operations of the four-cycle and two-cycle internal combustion engines are that in the four-cycle engine all operations take place separately within the cylinder above the piston while in the two-cycle engine, whether it be of the two or three port type, the operations take place on both sides of the piston, that is, within the cylinder and crank case, two operations occurring at each stroke, compared to one operation in the four-cycle engine.

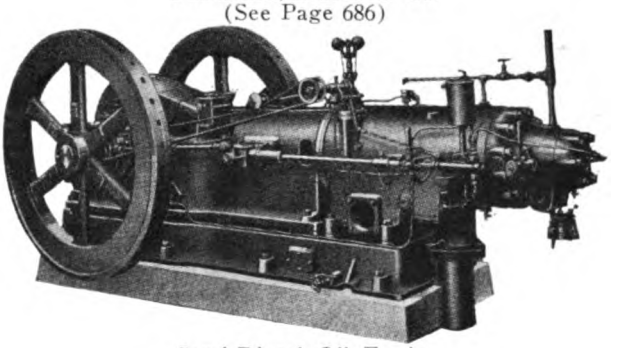
ENGINE (Oil). An internal combustion engine using crude petroleum or illuminating oil as fuel.



Kerosene Engine
Fairbanks, Morse & Co.
(See Page 686)



Oil Engine
Fairbanks, Morse & Co.
(See Page 686)



Semi-Diesel Oil Engine
The Chicago Pneumatic Tool Co.
(See Page 667)

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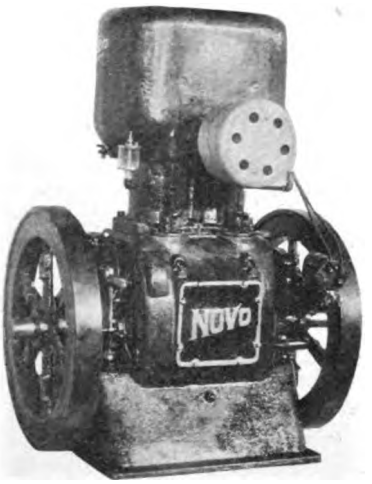

Novo Two Cycle Engine
The Novo Engine Co.

Oil engines are similar in design to gas engines but differ in the method of igniting the vaporized fuel. The fuel of the gas engine is mixed with atmospheric air before or during compression and is then ignited in the combustion chamber by an outside source of heat such as an electric spark, hot tube or hot chamber, while in the oil engine the liquid fuel, finely atomized by air under high pressure, is injected into the combustion chamber which contains only pure air. Through compression this air attains a high temperature, the fuel is at once ignited by means of a hot tube, plate or ball. The operation of the two and four cycle types is the same as in the gas engine. Claim is made that the oil engine will give reliable power from low grade fuel oils with the highest possible efficiency, consuming less of such fuel per horse power than other types of engines consume of higher grade oils. See Engine, Internal Combustion.

EXPLOSIVE. Any substance in which decomposition or combustion generates gas so rapidly as to expand with the sudden and violent force and usually with a loud report.

Gunpowder or black powder and dynamite are well known explosives which have been used for many years in railway construction, to blast trees or stumps in clearing rights-of-way and to make post-holes, to blast rock in making excavations and in driving tunnels, to move frozen earth and to break up log or ice jams which sometimes form above railway bridges. To safely explode dynamite time fuses are used when practicable. In under-water or ice-jam work electrical firing is frequently practiced with dynamite. In using explosives for blasting in rock for railway grades the drilled hole is usually "pop shot" first with a light charge of dynamite to enlarge the bottom of the hole to a chamber of sufficient dimensions to receive an extensive charge of explosive, usually black powder.

Black blasting powder is slow-acting, black and granular. It is made of sulphur, charcoal and nitrate of potassium or sodium, and grades from fine grain to coarse grain and cannot be detonated. It is packed in black corrugated tin cans.

Dynamite is made in cylindrical sticks, each in a special paper wrapper, the sticks being packed in saw dust in wooden cases. Gelatin, a higher quicker explosive is similarly made and packed.

Dynamite is a quick powerful explosive with a shattering effect. It contains nitro-glycerine and is graded by the percentage of gelatin it contains. It is low freezing but sometimes freezes in winter and should never be thawed at a fire or in an oven, but preferably steamed in a rubber blanket stretched over a tub or bucket of hot water, or better if available in a special kettle which has an inner watertight compartment for explosives.

Blasting caps or detonators are used to fire high explosives, and are themselves fired by means of safety fuse. Blasting should only be entrusted to licensed powder operatives who are men of experience and reliability.

EXPLOSIVE, GELATIN. A powerful and quick explosive made of gun cotton dissolved in nitro-glycerine in a warm water bath. It consists usually of 90 per cent of nitro-glycerine and 10 per cent gun cotton. It is of the consistency of stiff jelly, easily cut with a knife and when camphorated to reduce its sensitiveness is pale yellow. It is only more dangerous than dynamite when frozen. It is adapted particularly to tunnel blasting. See Explosive. Also Dynamite.

F

FALL LINE. A hoisting rope or cable which passes over pulleys at the end of a derrick boom, one end being fastened to the tackle block while the other is connected with the power unit. See Derrick.

FERRO-MANGANESE. An alloy of about 80 per cent iron and 20 per cent manganese which is added to carbon steel to produce manganese steel. See Manganese Steel. Also Alloy.

FIBER SATURATION POINT (Wood). The condition of wood when the cell walls are saturated with moisture and no free water is present. The moisture content of wood at the fiber saturation point is 20 per cent to 30 per cent of its oven-dry weight.

FILLER (PAINT). A preliminary transparent coating spread on the bare wood with a view to filling the grain and forming a smooth surface for succeeding coats of varnish or of paint.

Filler may be composed of raw linseed oil and finely ground silica, gloss or slate, or the vehicle may be varnish with combined thinner and drier, or any similar penetrating quick drying paste that is transparent and will not alter the appearance of the grain. See Paint. Also Varnish.

FINAL SET. A stage in the process of the hardening of cement when a load may be safely applied. See Standard Specifications for Portland Cement.

FLANGE. A projecting edge, rib or rim on any object as the base of a rail, or the top and bottom horizontal parts of a beam or girder, designed to furnish the necessary resistance to tension or compression in flexure. Flanges are generally cast on the top and bottom of iron columns to fasten them to other columns above or below. See Flange Cut, (Track Section).

FLARE LIGHT. A torch or lamp or other portable device designed to provide high candle power lighting for out-of-door night work.

Flare lights are commonly used in night work

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Milburn Portable Light
The Alexander Milburn Co.

Contractor's Portable Light
The Hauck Manufacturing Co.

Carbic Portable Light
The Carbic Manufacturing Co.

where large areas must be flooded with light to afford opportunity for workmen to perform their duties under night conditions approaching as nearly as possible those of daylight, as in emergency work such as clearing up wrecks and placing tracks in condition for resuming traffic, removing obstructions from track such as landslides, snow and ice and keeping track safe from wash-outs during high water, or handling locomotives, etc., at terminals and elsewhere in case of failure of the permanent lighting system.

The usual flare light is a self contained unit with a reflector and some suitable means of powerful lighting as of acetylene or other chemical light, electricity, etc.

These flare light units are carried in wrecking cars, snow plow cars, camp cars and other maintenance working equipment, ready for use, preferably in sets for throwing light from several points over the desired area to dispel shadows and so increase the efficiency of the operations.

FLATTING. A coating of paint which when applied to a surface leaves it without gloss. See Paint.

FLEXURE. The strain which occurs when a straight bar is subjected to a force or a combination of forces so applied that the axis of the bar is caused to assume the form of a curve, as the rails of a track under the wheel loads of a train.

FLUSH. In the same plane with. One surface may be flush with another, whether adjacent or distant. The plaster on a wall is flush with the adjacent stops; also the floor of a car may be flush with the freight house platform.

FOUNDATION. The lowest part of a structure, usually built under ground to distribute the loads to the earth beneath. Ordinarily foundations which are comparatively shallow may be utilized unless the structure involves loading which requires exceptional treatment. If the ground is comparatively unyielding the slightly widened masonry or other base is sometimes placed at the bottom of a dry excavation well below the frost line with adequate provisions for water proofing and drainage, usually the water is carried away through a line of drain tile placed at the base of the foundation, the filling over the tile being gravel cinders or some other porous material. The structure is also coated with waterproofing on the outside faces from the bottom of the foundation to the ground line, while provision is usually made if feasible to slope the earth away from the structure as a means of surface drainage.

If the bearing surface of the ground which it is practicable to reach economically with a foundation is inadequate, the ground must be compacted or reinforced usually with piling which act chiefly as columns if driven through soft material until their points stand on a hard stratum such as rock, or they act by skin friction if driven in yielding ground that holds them in place. The general practice is to drive foundation piles low enough so that their taps may support the foundation at the desired depth below the surface of the ground.

It being sometimes impracticable to obtain a suitable shallow foundation on a solid stratum or on piles and inadvisable to excavate through yielding ground to solid rock the spreading of the foundation is resorted to, usually by constructing over a sufficiently broad area on the yielding ground a slab of reinforced concrete to properly distribute the load of the structure. Consideration of spread foundations involves possible excavations in the near vicinity which may be deeper and disturb the material on which the slab rests.

Deep foundations are sunk to bed rock or other firm strata in open excavations when the ground is dry or when pumps will readily control the water;

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by means of open caissons under ordinary atmospheric conditions when the excavation is sealed with concrete, after which the remainder of the foundation is constructed without protection, by means of pneumatic caissons where the work cannot be done in the open; or with the aid of coffer dams to exclude the water from the foundation site during construction.

The character of the strata to be penetrated, including that on which the foundation is to be placed, together with the influence of water if any, and the economic restrictions are the chief factors in determination of the type of foundation to be used in individual cases. A foundation which is open to any question as to stability is poor practice even for a temporary structure, while permanent or semi-permanent structures should without question be placed on solid foundations. See Pile. Also Caisson. (Bridge Section). Also Spread Foundation.

G

GALVANIZE. To provide with a metallic coating to prevent rust.

The service life of iron and steel is prolonged by passing the metal, or preferably the manufactured article, through a bath of molten zinc. The noncorrosive action depends on the exclusion of air from the iron or steel which is electro-negative with respect to zinc, and thus uncorroded when the surfaces of the two metals are in contact. The metal surfaces should be clean, bright and devoid of all oxidation when the zinc coating is applied. Other metals have similar galvanic relations. See Iron Kalamined.

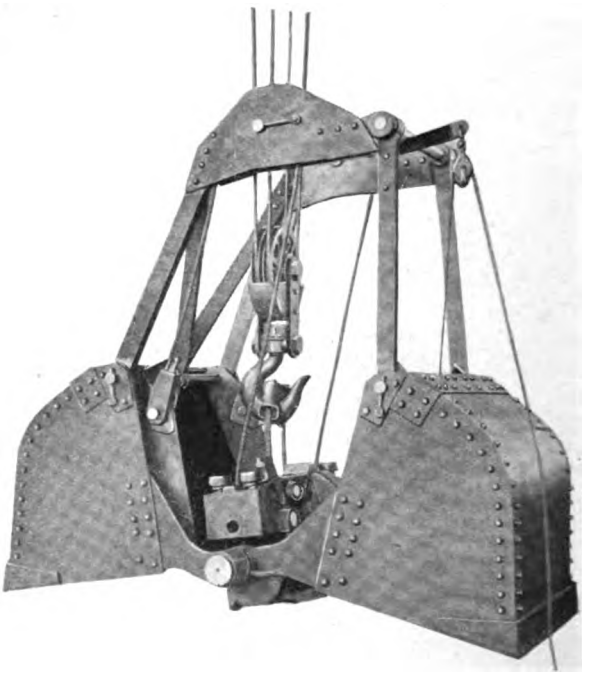
GALVANIZED SHEET IRON. Sheet iron covered with sal ammoniac, after first being cleaned in a bath of dilute acid and then coated with zinc by immersing it in a bath of the molten metal. An amalgam of 11.5 parts zinc and 1 part mercury is sometimes used. Galvanized iron is usually made in sheets about 2 feet wide by 6 to 9 ft. long, and its thickness is measured by its wire gage number. Galvanized sheet iron is extensively used for roofing, ventilators, gutters, downspouts, siding, stackes, culvert pipe, etc. It is water tight, fire proof and adaptable to shaping while corrugating adds markedly to its strength. As a building material it is easily transported and erected and a ready conductor of heat and sound.

GALVANIZED WIRE. Iron wire which has been drawn through a bath of molten zinc with a view to protecting it from rust, thus prolonging its service life. The wire is first cleaned, preferably with acid, and is afterward drawn through a trough of liquid zinc and mechanically wiped in such a way as to obtain an even protective coating of sufficient thickness and adherence to withstand being wiped dry after each one of four one-minute immersions in a copper sulphate solution of 1.185 specific gravity, without removal or the formation of a copper-colored deposit. See Galvanize. Also Galvanized Sheet Iron. Also Iron Kalamined.

GASOLINE. A volatile, colorless liquid obtained by distilling crude petroleum, and consisting of a mixture of various compounds of carbon and hydrogen gas which are not physically or chemically constant. Its chief use is for motor fuel, the first essential of which is the characteristic of volatility or quickly turning from a liquid to a vapor. Gasoline is not of itself explosive though it is inflammable, but when mixed with air carbonic gas is formed by the carbon while the hydrogen burns to water, the gas exploding with a sharp, keen report, generating great heat from which the power of gas engines is obtained. If the combustion is incomplete the unburnt carbon tends to collect on the machine parts and to interfere with ignition of the gas. The proper mixture for gas engine fuel is 1 part of gasoline to 15 parts of air. See Engine, Internal Combustion.

GRAB BUCKET. A sheet steel machine scoop resembling a basket hung from a bale at the end of a wire rope depending from the boom of a crane which lifts and swings it, the container or tray being made in two equal parts, (or sometimes in three or four) arranged to spread apart at the bottom when operated to drop into the material and to grip together before rising, digging down as they converge until the sharp edges meet beneath the load.

The bucket with the two piece tray is known as a clam shell from its manner of opening and closing the two parts, while the three or four part type is commonly called an orange peel from its resemblance to the skin of an orange divided into equal pointed portions. The clam shell is useful in transferring fuel, gravel, crushed stone, earth, sand and any other loose material wherever it can be vertically



Brosius Grab Bucket
Edgar E. Brosius

lifted and dropped, as coal from open topped cars to locomotive tenders, gravel or stone from barges to concrete mixers, clay from open excavations or ashes from submerged ash pits. They are also useful in dredging and are employed in connection with any kind of crane or derrick of sufficient capacity.

While ordinarily the loading of the bucket depends on the pull of the lifting line to close the trays, the closing may be accomplished by means of an electric motor operated winding mechanism placed in the

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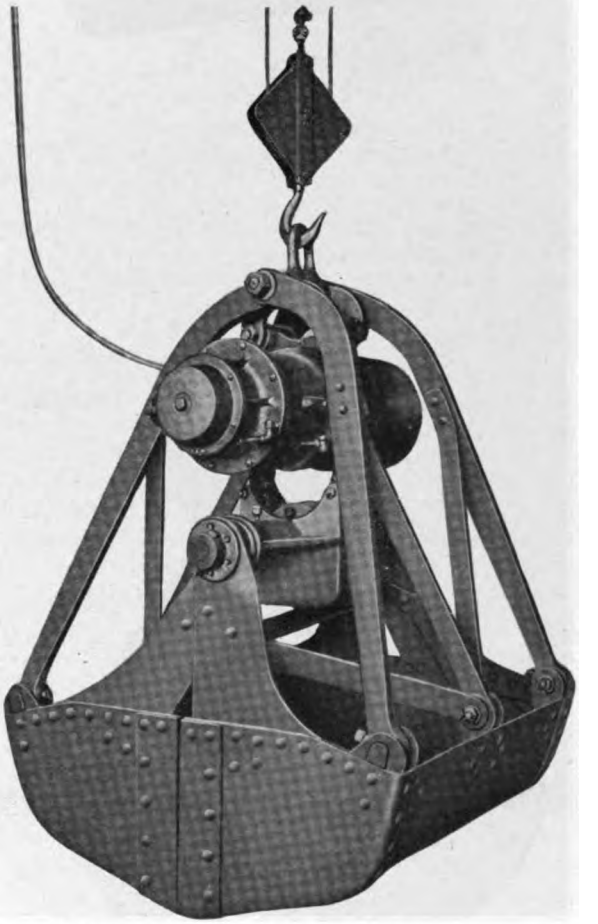
Browning Flat Chain Clam Shell Bucket
The Browning Co.

Haiss Contractor's Bucket
The George Haiss Manufacturing Co.

Angular Bottom Clam Shell Bucket
The Lakewood Engineering Co.



Electrically-Operated Clam Shell Bucket
The Hayward Co.
(See Page 705)

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Multi-power Clam Shell Bucket
The Industrial Works

Clam Shell Bucket
The Hayward Co.
(See Page 705)

Clam Shell Bucket
The G. H. Williams Co.

Three Point Orange Peel Bucket
The Hayward Co.
(See Page 705)

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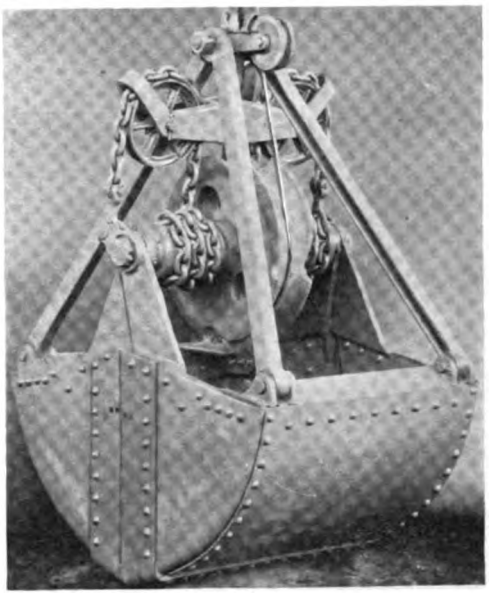
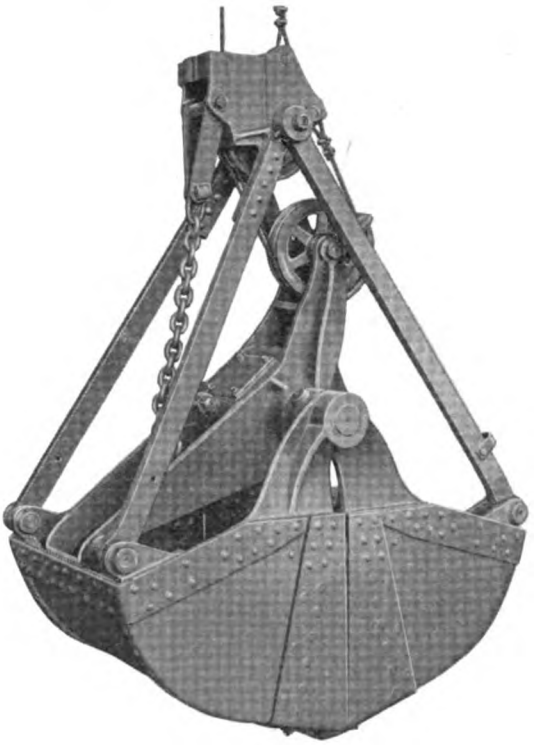


Chain Operated "U" Grab Bucket
The Mead-Morrison Manufacturing Co.



Blaw Dreadnaught Bucket
The Blaw-Knox Co.

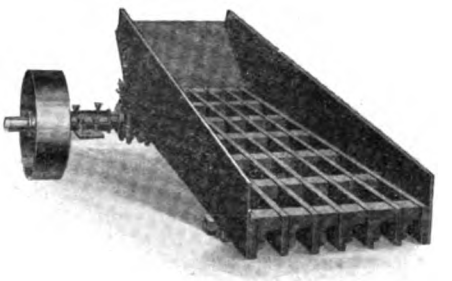
head close beneath the axle from which the bucket is suspended. While grab bucket trays vary somewhat in shape, the bottom when closed is generally rectangular in plan with upturned ends, while the parallel sides of the tray are riveted at right angles to the bottom plate, the halves of each side being joined at their top meeting point on the two ends of the hinge shaft, while the side bars or arms, diverging from a common top axle or some similar arrangement are attached to the upper rims of the sides on the scoop shaft. The blocks and cables are variously arranged but there are upper and lower blocks, or a power wheel located on the hinge shaft or some similar operating arrangement.

Some trays are perforated for handling wet materials and others have teeth secured to the lips similar to steam shovel teeth, for handling loose rock.

The orange peel bucket is identical in general arrangement and operation with the clam shell, its sharp pointed scoops being especially adapted to excavating from restricted areas such as dredging from open caissons and from the insides of steel cylinders to be sunk for bridge piers, etc.

GRILLAGE. A series of closely laid, cross-piled beams, usually fastened together and used as a base or a spread foundation to distribute loads to the stratum below. Grillages are frequently useful in bridge and building construction, being employed under columns, as bearings for bridge spans, etc.

GRIZZLY. A wide, shallow trough conveyor designed to deliver large rock one by one into the hopper of a crusher to prevent the material from crowding and clogging the machinery. The trough has vertical sides and a bottom consisting of a series of longitudinal parallel fixed steel rods alternated with



Bulldog Grizzly
The Traylor Engineering & Manufacturing Co.

lower liftable walking rods which are raised and moved forward, then lowered and moved back by a wide bottom eccentric, each revolution of which advances the large rocks a step toward the hopper while the smaller particles fall between the rods. See Ballast Crusher, (Track Section).

GROUND SWELL. The rapid increase in diameter occurring near the butts of some piles and poles, and sometimes found in cross-ties.

In the growing tree the ground swell is usually at its maximum at the surface of the ground, diminishing rapidly upward to the normal circumference of the trunk a few feet above.

GROUT. A mortar of liquid consistency which can be poured easily. (A. R. E. A.)

Grout may be made of cement and sand, usually a rich mixture, such as one part of cement to two parts of sand. It is frequently used to fill cracks in masonry, or it is poured into anchor bolt holes about the bolts to hold them securely in place when it has hardened, or it is used as a finish coat for the face of a masonry wall.

GUMBO. A peculiarly tenacious, fine grained, silty clay devoid of sand but rich in alkaline compounds, which is impervious when saturated with water, waxy in appearance, soapy to the touch and a suitable material for burnt clay ballast. It is widely distributed over several of the states of the middle west. See Ballast, (Track Section).

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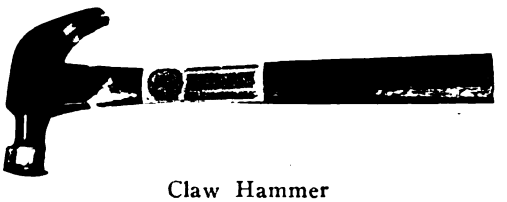
H

HAMMER. A beating or striking tool having a solid head set crosswise on a handle, and used for driving nails and rivets, breaking stone, beating metal, etc. The head is usually of steel and the handle of wood. Various machine tools which drop heavy blocks or drive pistons are used for a like purpose. See Steam-Hammer. Also Pile-driver. Also Hammer, Pneumatic. Also Riveting Hammer, (Bridge Section).

HAMMER, CLAW. A woodworker's hammer used for driving and pulling nails.

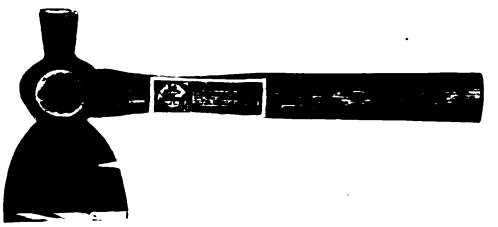
The claw hammer consists of a steel striking head tapering to a backward curved nail-pulling claw. A



Claw Hammer

central adz eye penetrates the casting from front to back and is extended to form a socket to strengthen and protect the end of the straight wooden handle which is about 16 in. long. The striking face terminates the cylindrical or necked poll while the sharp, wedge-shaped prongs of the claw on the opposite end have inside, adjacent edges slightly beveled to grip a nail beneath the head.

HATCHET. A chopping tool used to cut wood and sometimes to drive and pull nails.



Shingling Hatchet

The common hatchet has a flat steel head with a driving end or poll, and an oval central eye from which the blade which has a side notch for nail pulling flares to a thin, wedge-shaped, beveled cutting edge.

HATCHET, BROAD. See Ax, Hand.

HOLLOW HORNING. See Case Hardening, (Wood Preservation Section).

HONEYCOMBING. See Case Hardening, (Wood Preservation Section).

HOOK, SCAFFOLD. A metal bar or rod, the ends of which are reversely curved or bent square in opposite directions to form hooks used by structural erectors and painters to support a scaffold. One end of the hook is hung over a convenient member of the structure while the other end supports blocks, ropes, etc., to which the scaffold is attached.

HYGROSCOPIC MOISTURE. Moisture intimately absorbed by the substance of the cell walls, as distinguished from free water, small particles of which occupying the capillary spaces of green wood, are given up without shrinkage, while the slightest reduction of hygroscopic moisture below the fiber saturation point causes shrinkage. See Wood, (Wood Preservation Section).

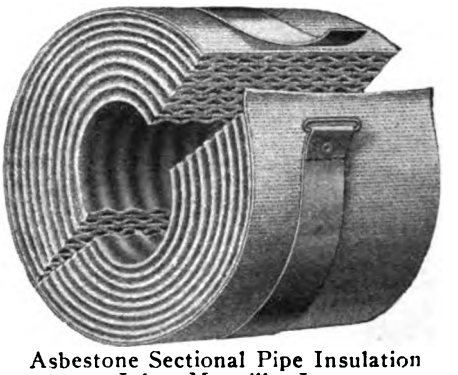
I

INGOT MOLD. A rectangular, bottomless container for molten steel, usually 18 to 29 in sq. in section by 5½ ft. to 7 ft. long. Ingot molds are used to convey the molten metal from the furnace to the stripper, a machine which removes the molds when the contents have solidified. See Steel.

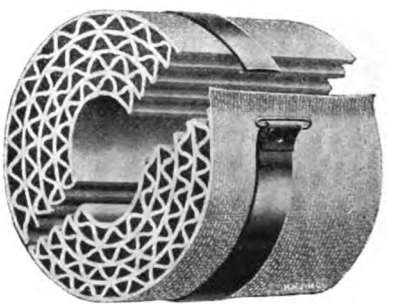
INITIAL SET. An early development in the process of setting, marked by a certain hardness in cement concrete. (A. R. E. A.)

The initial set of Portland cement, as specified by the A. R. E. A. must take place within 30 minutes from the beginning of the test.

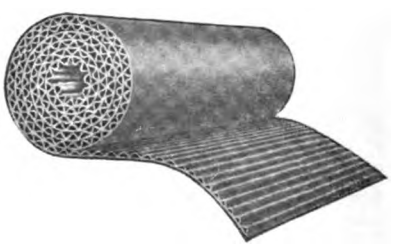
INSULATION. A device or a material that interrupts communication, as of currents of electricity, heat, cold, sound, etc., as a fiber end posts insulates



Asbestone Sectional Pipe Insulation
Johns-Manville, Inc.
(See Page 722)



Air-Cell Sectional Pipe Insulation
Johns-Manville, Inc.
(See Page 722)



Asbestone (in flexible roll form)
Johns-Manville, Inc.
(See Page 722)

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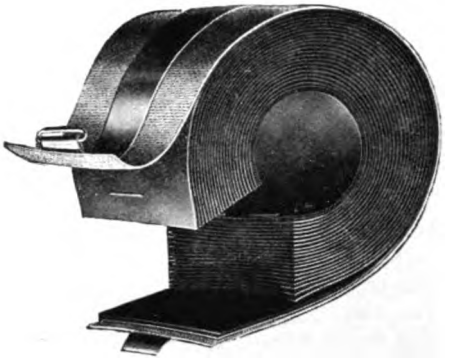
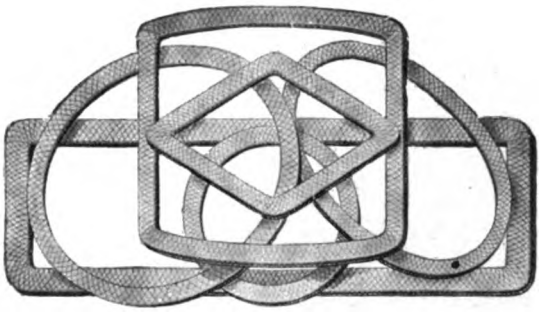
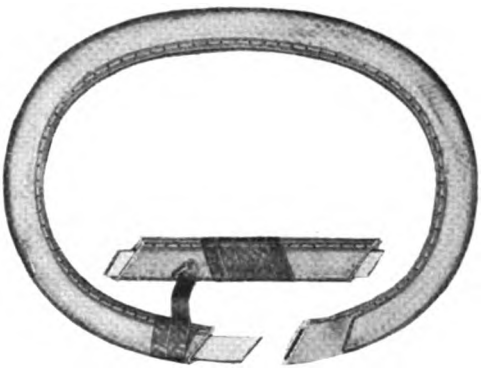


Anti-Sweat Sectional Pipe Insulation
Johns-Manville, Inc.
(See Page 722)

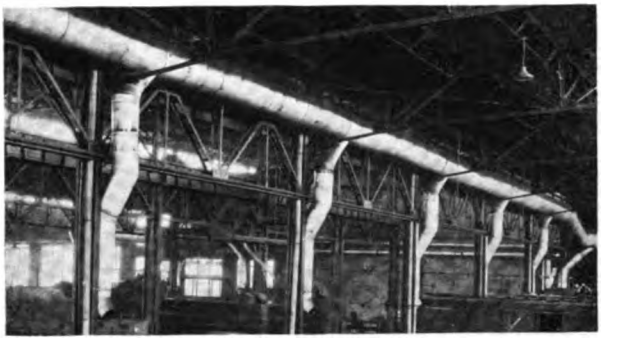


Special Tube Plate Gaskets
The General Asbestos & Rubber Co.

Semibronze Asbestos Metallic Sheet Packing
The General Asbestos & Rubber Co.



Garco Adjustable Gasket Tape
The General Asbestos & Rubber Co.



Insulation Covering on Pipes
Johns-Manville, Inc.
(See Page 722)

abutting rail ends, an asbestos pipe covering prevents heat from escaping, an air space between ice house walls saves ice and an insulating felt between floors deadens sound.

In the building trades tar paper and building paper are largely used on wall sheathing and roof boards for insulation. The material is used from the roll the sheets being lapped and tacked in place on the boards before placing the siding or roofing. Both these papers are made in various weights and are used on all sorts of roofs. A common custom is to lay building paper on the sheathing, with a layer of tar paper over it beneath the roofing and siding. Insulating felts in sheets from ¼ in. to ⅜ in. thick are largely used in walls and between floors as insulators. Back plastering is an insulating device, introducing wall of lath and plaster between the sheathing and the inside lath and plaster thus providing an additional air space as well as an extra wall. Asbestos pipe and boiler coverings are made of cellulose asbestos in order to provide air spaces between the surfaces. Concrete blocks are preferably made with hollow central portions with a view of providing insulation through having an air space in walls. Hollow tiles are placed above the windows in engine house walls to take care of condensation, and are favored for building walls in general because of the air space provided.

IRON. A metal rarely found in pure metallic state but existing in abundance as iron oxide, the ore mined containing 25 to 70 per cent iron with varying small percentages of silicon, sulphur, phosphorus and earthy impurities. Hematite, the principal red iron ore of commerce is a dry oxide of iron. Brown hematite (hydrated ferric oxide), magnetic oxide and brown granular carbonate of iron are other varieties mined.

Iron ore is melted down in a blast furnace to obtain pig iron, which contains about 93 per cent iron, 3 to 5 per cent carbon and varying small percentages of silicon, sulphur, phosphorus and other impurities. The charge of ore and fuel is put in at the top of the blast furnace, a cylindrical brick tower 75 to 100 ft. high and a hot air blast forced in at the bottom to burn the fuel and melt the ore which runs out at the base. This operation is continuous, with periodical recharging and tapping, the heat being produced by the burning coke and the limestone combining with the impurities to form a slag, which is tapped away from the heavier iron.

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Pig iron is remelted to make iron castings and all kinds and grades of steel and wrought iron. Pig iron and cast iron contain about 4 per cent of carbon, while wrought iron has only a trace and the carbon content of steel is between these extremes.

IRON, PIG. Metallic iron reduced from its ores which are oxides, by melting with carbon and a flux; commonly coke and with limestone.

Heated air from blast stoves is forced into the furnace under air pressue to increase the heat of the burning coke and to decrease fuel consumption. Gases are drawn off at the top, liquid impurities float on the iron and are tapped away separately, while the heavier metal is removed from the bottom of the furnace. The liquid iron is allowed to run into depressions in a sand covered floor or into iron molds where it cools, forming billets called pigs, usually semi-circular in section and of suitable length and weight for convenient handling and shipment. See Iron.

IRON, KALAMINED. Sheet iron, coated with an alloy of zinc, tin and nickel in the proportion of 29 lb. of tin, 50 to 75 lb. of zinc, 100 lb. of lead, and 3 oz. to 6 oz. of nickel. The alloy melts at a lower temperature than common zinc, and is claimed to give more durable compound as well as a thinner and more adhesive coating. Kalamined iron is used extensively in the manufacture of heat resisting facilities, such as fire doors and factory window shutters.

IRON, PURE. Iron made of equal parts of selected pig iron and scrap tested for purity, heated for fuel containing less than 1 per cent sulphur, tapped at 3,100 deg. F., degassified with aluminum and specially worked.

Pure iron is notably corrosion resisting and long lived. Its melting point in spelter is comparatively high, resulting in minimizing the iron content and increasing the service lift of galvanized coatings. This material is extensively used in the manufacture of nails, galvanized wire fencing and metal posts, culvert pipe, gutters and down spouts, sanitary containers, etc. (See Page 638).

L

LADLE (STEEL-MILL). A large brick-lined pot of riveted steel plates, having at its base a discharge nozzle and a stopper, and designed to hold molten steel tapped into it from the furnace, whence it is poured into the ingot molds by removal of the stopper. See Steel.

LAITANCE. A film or layer consisting principally of the finer cement particles which rise to the surface during the placing of concrete. (A. R. E. A.)

Laitance is a gelatinous, whitish substance formed apparently from the disintegration of particles of the cement due to the action of water on the surface of freshly made concrete. If left on the surface laitance tends to weaken the bond between old and new concrete, as although its composition is about the same as cement it has little or no hardening qualities.

LUBRICATION. The application to moving surfaces in contact, such as parts of machines, of a substance to prevent friction, such as oil, grease, plumbago, etc. The existence of friction, or that force which acts between two bodies at their surfaces of contact to resist their sliding upon each other, necessitates the employment of a medium through which the resistance and heating, caused by motion of the parts in contact, will be reduced. Lubricants of various kinds, depending upon the conditions to be met, are employed for this purpose. The light oils give best results where the bearing pressures are low and speeds high. These are obtained almost entirely from the mineral products, although some are of a vegetable origin, such as castor oil, which is particularly valuable under conditions where a high degree of heat is encountered, as in internal combustion engines. Heavy grades of oil are necessary under conditions where the load and speed would crush and "wear out" the lighter oils. The greases and solid lubricants, such as animal and vegetable fats, soapstone, graphite, etc., are desirable for slow moving bearings under heavy loads where the friction is not excessive.

The value of a lubricant to decrease friction depends upon its ability to maintain an oil film between the surfaces. This characteristic is influenced, however, by various factors, such as pressure and speed of the parts in contact, foreign matter in the lubricant and faulty application. With these factors removed, it is a matter only of a suitable lubricant.

For different purposes, various lubricants are required, but in each case the "body" or viscosity should be sufficient to withstand the pressure upon it, or in other words have the characteristic to maintain a film between the parts sufficient to prevent the parts coming in contact with each other. Mineral oils are used for nearly all commercial lubrication purposes.

The qualities of a good lubricant are: (1) Sufficient body to keep the surface free from contact with each other under maximum pressure. (2) The greatest fluidity without impairing the "body." (3) High flash point. (4) Freedom from corrosive impurities.

Satisfactory lubrication depends as much upon the method of applying as upon a suitable lubricant. Various methods of application are in satisfactory use, most common of which are: gravity, force, splash and capillary action feeds or the oils, while friction and heat are employed to apply the greases.

M

MATERIAL TESTING. The proving of the quality of materials by scientific investigation based on accepted standards and on methods recommended as a result of research and experience in the making of materials and the manufacture and use of devices containing them.

Standard specifications or methods of making have been evolved for iron and steel of various kinds, for cement, railway rails and fastenings, structural steel, reinforcing bars, gas and water pipe, sheet iron, galvanizing, drain tile, air hose for pneumatic tools, wire, structural timber, lumber, cross ties, switch materials, etc. It may be the duty of the material tester to inspect the making of a material from the first handling of the product of the mines or other source, through each step in combination, with special attention to the uses to which the finished material is to be devoted, reporting meanwhile on the

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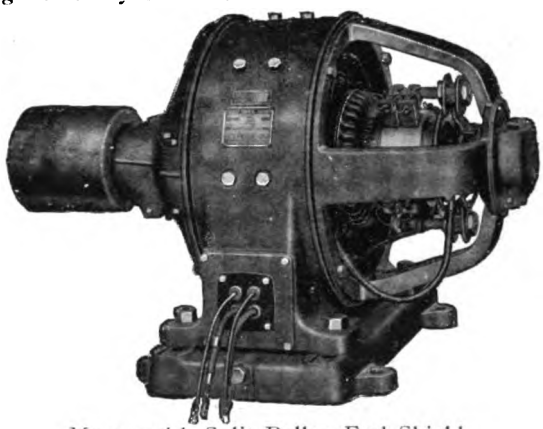
results of the progress of manufacture or the inspection may be limited to the performance of certain specific tests on the finished product. Inspection of finished articles such as rails, is made on samples which are tested chemically and mechanically to indicate the worth of the material. The results obtained are observed with a view to comparison by these practical tests under like conditions, such as the service life of a high speed tool, the endurance of water pipe under pressure, etc. (See Page 709).

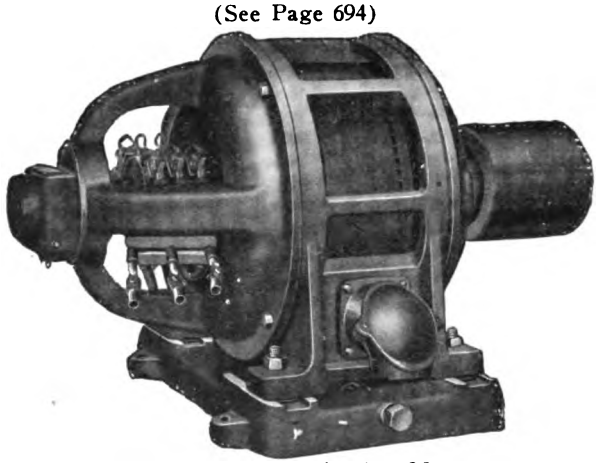
MAUL. A beating and striking tool, usually a heavy hammer or mallet. Mauls formerly made of wood are now usually of metal such as cast steel, and have conical or tapering double-faced heads or single faced heads with variously shaped peens for special uses. The central oval eye extending through the casting from front to back designed to hold the end of a straight wooden handle. See Sledge.

MOTOR, ELECTRIC. An electro-mechanical machine for transforming electric energy into mechanical energy, consisting essentially of a revolving member and a stationary member.

It is used as a means of driving machinery such as electric generators, pumping apparatus, machine tools, electrically operated switches and signals, etc. The size and type of the motor is dependent upon the work it is to perform. A motor depends for its operation on the tendency of an electrical conductor carrying current to move in a magnetic field or on magnetic attraction or repulsion. A magnetic field may be produced by permanent magnets, electromagnets or by current.



Motor with Split Pulley End Shields
The General Electric Co.
(See Page 694)

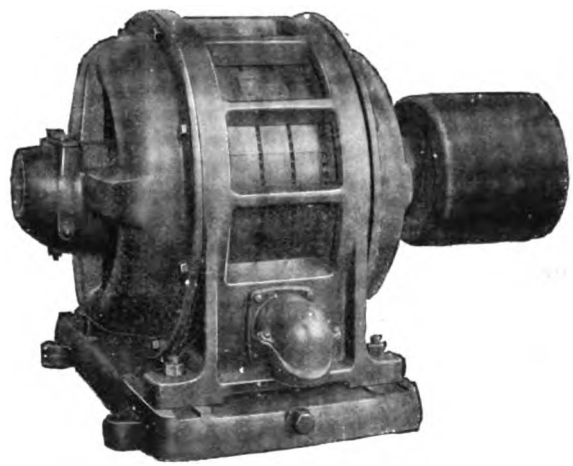


Collector Ring Induction Motor
The General Electric Co.
(See Page 694)

Motors may be divided between those operating on direct current and alternating current. Direct current motors are of three types; series wound, shunt wound, and compound wound. The series motor is useful in cases where powerful starting torque and rapid acceleration are required without a heavy instantaneous demand of energy. A valuable feature of this motor is that maximum torque is obtained at low speed. However, if this motor is used on light loads dangerously high speeds may result and for this reason the motor should be connected directly or geared to its load. The speed on a constant voltage varies automatically with the load.

The shunt motor is one having practically a constant speed which varies but slightly with fluctuations of the load. For loads where the torque remains constant regardless of the speed, speed regulation is obtained by varying the voltage impressed on the armature, several systems being designed for this purpose. Another method of speed regulation is the insertion of resistance in the shunt field circuit. Motors with this type of speed regulation are of constant output but not constant torque as the torque falls in proportion to the increase in speed.

The compound motor is provided with a series and a shunt field, usually connected so that they are in the same direction. Such a motor is called a cumulative compound motor while a differential compound motor which is sometimes employed for special service has the two fields opposing. The ordinary cumulative compound motor combines the shunt and series motor characteristics. Its speed does not vary greatly under changing loads and it has a powerful starting torque which increases with increased load. In shop practice a motor is generally required to maintain an approximately constant speed after starting or when the load is removed and must start



Standard Skeleton Frame Induction Motor
The General Electric Co.
(See Page 694)

under heavy load. A comparatively weak field is required for motors of this type. The speed regulation of these motors is accomplished in a similar manner to that for a shunt motor.

Alternating current motors, single phase and polyphase, may be classed under several types as synchronous, synchronous induction, induction (of which the phase wound and squirrel cage motors are types) and commutator types. A synchronous motor has constant speed which is fixed by the number

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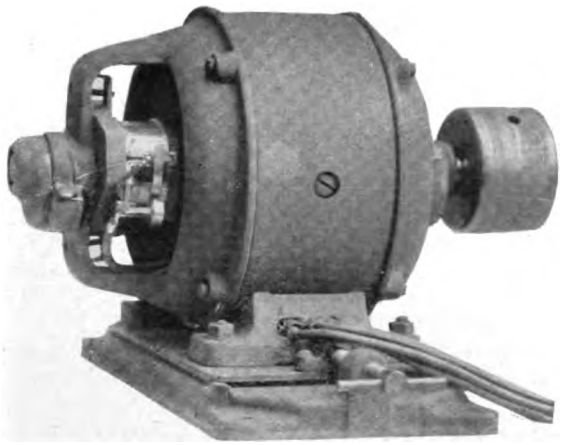

Belt Drive Electric Motor
The Westinghouse Electric and Manufacturing Co.

of poles and the frequency of the impressed e. m. f. These motors are generally not of the self-starting type but may be made so if necessary.

The induction motor is of two types the squirrel cage and the phase wound and has constant speed. The speed, however, may be varied by placing resistance in the rotor (rotating member) circuit or by varying the applied stator frequency. The squirrel cage type has a relatively small starting torque per ampere. It is used for constant speed service with infrequent starting.

In the smaller sizes it may be designed for a high starting torque, frequent startings and rapid acceleration by increasing the resistance of the rotor. The wound type of induction motor is best adapted for service requiring high starting torque combined with a moderate starting current. Where the operation of machinery requires two or three speeds which must be independent of the load, multi-speed induction motors may be used in which the different synchronous speeds are produced by changing the number of poles in the magnetic circuit.

Under the cummutator type of motors, the single phase series motor has a very powerful starting torque, relatively high efficiency and high power factor and the speed is controlled by varying the applied voltage while the repulsion induction motor has a limited speed and an increase of torque with a decrease in speed. The repulsion motor may be designed for reversible service and variable speeds.

Both d. c. and a. c. motors may be further classified as to speed, as constant speed, which is constant or varies only slightly; adjustable speed, which may have a considerable range, but once fixed remains at this value independent of the load changes; varying speed, in which the speed changes with the load, generally decreasing as the load increases, and multi-speed, where several different speeds may be obtained by changing winding connections or by other means.

Another classification of motors based on their mechanical characteristics divides them between the open type; mechanically protected; semi-enclosed; totally enclosed; enclosed but ventilated externally; enclosed and self ventilating; moisture; proof; splash and water proof; submergible, acid proof and explosion proof.

The principal limitations of motors are based on their commutation, efficiency, regulation, mechanical strength and heating. Electric motors, properly installed together with protection and safety appliances, furnish satisfactory driving power, require little attention and can be relied upon to function continuously at a moderate expense and to develop a high rate of efficiency. They will permit the attendant to perform duties at other points, even while the machine is in operation so that the operating expense is small compared with any other power machine. Under some conditions it is sometimes desirable to apply stopping and starting devices to electric motors, which make the machine applicable to automatic control. Such devices as circuit breakers, pressure diaphrams or other apparatus, depending on the conditions to be met, will stop the motor automatically on the completion of a task such as the raising of the water in a tank to a predetermined level and when the task is to be repeated the apparatus will start the motor automatically. This type of control is also used for maintaining a practically constant air pressure for the operation of pneumatic tools.

N

NAIL, DATING. A galvanized or copper nail with a large head, in which the last two numerals of the year are stamped. These nails are sometimes driven into the upper faces of ties to indicate the year in which they were treated, or laid. More often, as a matter of record, test sections of one or groups of ties are laid, variously treated all ties in the section being installed at one time, and the ends of the section being marked with posts, which may bear the date. Nails are sometimes used to indicate the age of timber other than ties, such as piling, etc.

Dating nails are commonly diamond pointed and are sometimes provided with opposite corrugations on the shank beneath the head, to increase their holding power in timber.

O

OIL CAN. A metal container for lubricating oil, fuel oil or illuminating oil.

Oil cans may be hand oilers or quantity containers. An oiler is a can from which the oil is poured direct-

Five Gallon Oil Supply Can
The Eagle Manufacturing Co.
(See Page 683)

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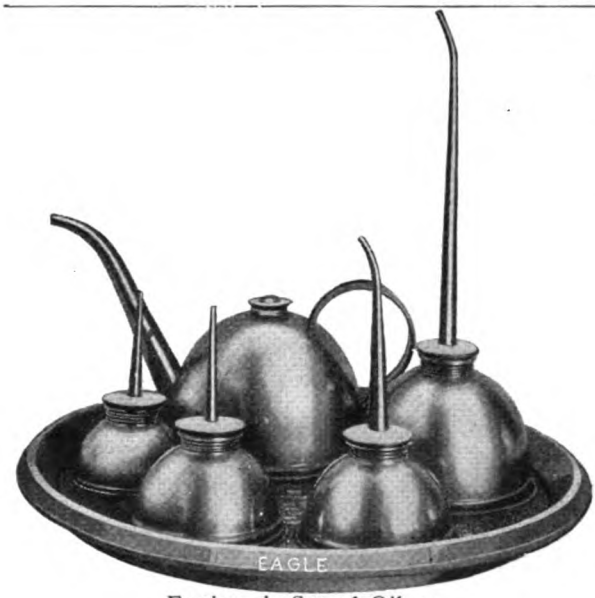

Engineer's Set of Oilers
The Eagle Manufacturing Co.
(See Page 683)

ly into the machinery and commonly has a container holding a pint or less, and a long, slender spout from which a fine stream of oil may be directed to the oil hole or other portion of the machinery. The larger oil cans are used as supply containers from which oilers, lamps, etc., are replenished.

OPEN-HEARTH PROCESS (STEEL MAKING). The reduction of pig iron and steel scrap to steel in a shallow, rectangular arch roofed basin by means of gas flames directed by drafts of air above the basin. See Steel.

ORANGE PEEL. A grab bucket with a tray composed of three to four equal sharp-pointed scoops which when closed meet in a point at the base, their outwardly convex triangular plates constituting a round bottomed bowl like the peels of half an orange cut vertically in equal parts.

The orange peel is furnished with operating machinery similar to that of the clamshell. It is used in connection with derricks and cranes for under water dredging, and especially for handling sticky materials, etc. These buckets are made in capacities ranging from 100 cu. in. to 5 cu. yds. or more, a common size being the 1 cu. yd. bucket. See Clam-shell. Also Grab Bucket.

OUT OF WIND. Having the longitudinal surfaces plane (A. R. E. A.). This term is applied to sawed timbers, the surfaces of which are free from defects caused by warping, irregular sawing, planing, etc.

P

PAINT. Any dry coloring matter, or pigment, mixed with a liquid vehicle, (such as linseed oil with thinner and dryer) so as to be readily dipped or applied with a brush or spray to any surface to protect it from the weather or to give it any desired color. Paint differs from stain in that while the stain is intended to sink into the wood or other surface to which it is applied, the paint made to give it a non-transparent protective surface coating of considerable body. Therefore the paint is applied in two or more successive coats, over an initial priming coat, which tends to prevent the body coats from sinking into the wood.

The ingredients of paint are frequently mixed by hand as needed, by experienced painters. The hand mixing process requires a knowledge of colors and of the proportions of ingredients necessary to produce a paint of the proper consistency and quality.

For building work in general the dry paint is nearly always mixed with linseed oil; the mixture being thinned with turpentine and volatile mineral spirits which acts as a solvent. The greater the oil content in paint the more gloss there is in the finished work; hence it is common to use almost pure turpentine for flatting or mat work. White carbonate of lead, the white lead of commerce, forms the body of most paint, pure for white work and mixed with other powdered pigments for other colors, a single dark pigment or a mixture of two colors being used to produce the required shade. There are various fireproof paints, water-proof paints, smoke proof paints, luminous paints, bridge paints, building paints, etc., but the essential function of all of them are to protect the material covered from the effects of exposure; the color being a matter of secondary importance. Red lead and oil are commonly specified for the shop coat for the structural steel, while machined surfaces are coated with white lead and tallow to prevent rusting. Red lead paint commonly consists of about 60 per cent pigment and 40 per cent liquid, the pigment being red lead and the liquid a refined linseed oil, with thinner and dryer. This paint should weigh 16 lb. or more to the gallon and should dry without sagging, running or streaking. It should be applied to the steel work as promptly as possible during fabrication.

Building primers are made of oil and comparatively small percentages of pigment. They are preferably applied to mill work before delivery, and as soon as possible after milling. If the wood work is to retain its natural grain and color a wood filler is used after the initial sand papering. This material may be any penetrating, transparent, quick drying liquid, such as a mixture of varnish and turpentine with about 15 per cent of finely ground silica, powdered glass or ground slate. Filler should dry in five hours or less after application.

The relative qualities of the various kinds of paint are matters in continual controversy largely because of a lack of concise knowledge of how, when and where to use the material and of what may be expected of it under diverse conditions as well as indifferent mixing and care in cleaning the surface before applying the paint.

The best results are probably obtained by selecting the standard line of some reputable manufacturer, by accepting his expert advice concerning what paints to use under each condition of service, and by keeping careful records of performance. See Painting. (See Page 797).

PAINTING. The process of preparing and covering surfaces with paint with a view to protecting them from exposure and secondarily of giving them color.

There are three general methods of applying paint, (1) to spread the material on the surface with brushes by hand (2) by using compressed air spraying machines and (3) by dipping the object into a

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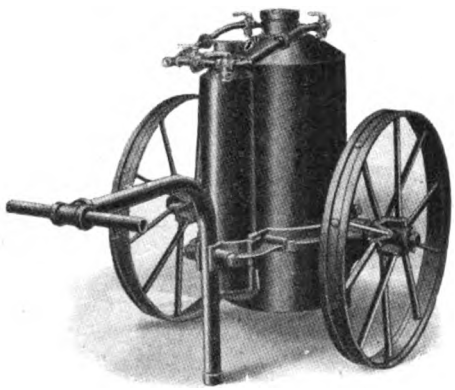
vessel containing the paint. Hand brushing is equally efficient for extensive plain surfaces and for the finest trim. It requires skilled workmanship, the total cost of labor being frequently more than the value of the material used. The work requires scaffolding, etc., to reach otherwise inaccessible parts of structures, involving danger of injury to the workmen. Paint spraying is accomplished by holding an atomizer within 8 or 10 inches of the surface while the pressure of some 40 lb. to 50 lb. of compressed air is exerted on the paint in the tank, the usual

The Spraco Paint Gun
The Spray Engineering Co.



Viloco Portable Painting Machine
Harry Vissering & Co.
(See Page 831)

power being electricity or a 2 h. p. to 4 h. p. internal combustion engine. The paint used is as thin or 10 per cent thinner than brush painting solutions, coarse particles tending to clog the spray, which is advantageous in saving labor especially in extensive surface painting, in reaching surfaces which are inaccessible or difficult to paint with a brush and in covering rough surfaces. Spray painting is sometimes done with the aid of compressed air from mechanical tie tamping compressors.

Dipping is a process commonly confined to painting articles that can be immersed in an open vat. An advantage is the saving of labor, while there is no doubt that the submerged surfaces will be covered. The application is limited to the capacity of the vat, while the amount of paint that is in constant use is a consideration. This process is frequently used to cover the grounds of small roadway signs for stencil work, such as metal plates for bridge and culvert numbers.

The preparation of surfaces, especially for field painting is of first importance. It is tedious, exacting labor too often slighted without detection until the paint scales, cracks or peels off the surface. Given a clean ground the paint can only be applied with proper success when the surface is perfectly dry, moisture being considered the greatest enemy to good painting. Bridge steel is cleaned by means of sand blasts, (except the heavier scales which must sometimes be chipped off) or with wire brushes, chipping hammers, brooms, etc. The sand blast is a compressed air jet of fine sand from a special hose. Care is necessary to avoid "digging into" the steel and to have fine sand thoroughly dried to avoid clogging the machine, which may be used in this or other forms for removal of rust from any iron or steel casting, which is desirable as a preliminary to painting. Wood surfaces are prepared by burning and scraping off the old paint, by sand papering all rough spots, by puttying nail holes and, especially on inside work, by scrubbing the surfaces and allowing them to thoroughly dry before painting.

Interior painting is the process of covering surface with colors or with pigments mixed with water and glue, called water color, kalsomine, or distemper. Such inside work frequently includes work done with a transparent glaze made with shellac or varnish; the treating of wood with shellac and oil, or with wax and other materials in successive coats, rubbed down between the pumice-stone and oil, to polish their surfaces and bring out their grain and natural color; and the staining of wood surfaces without concealing the grain. The painting should supplement form with color, correcting errors of proportion if any by a judicious choice and comparison of colors, apparently to lower a room which is too high, or to heighten one which is too low, etc. Light may be added by using light tints and white or cream on ceilings, the white color being of advantage especially where indirect artificial lighting is used.

Cold in itself is not injurious to good paint and painting. Paint is successfully applied out of doors in winter, care being taken that there is no frost or snow on the surface, the work preferably "following the sun" and being done preferably during the two or three hours before and after mid day. Field grinding and mixing of paints is best done mechanically, a great deal of paint being wasted or spoiled because the pigment which has precipitated in the barrel or can is not thoroughly agitated and the proper consistency of the liquid restored. If the material in the bottoms of paint barrels was mechanically remixed and if necessary, reground in the paint car, large economies would result that are seemingly unobtainable in most cases where hand remixing is the only method available. The proper spreading of paint is a trade closer allied to an art than to common labor. The value obtained in return for the expenditure is in direct ratio to the excellence of the material used and the skill with which it is applied. See Paint.

PARAPET. A wall or barrier constructed on the edge of a masonry structure for protective purposes and sometimes for ornamentation.

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PICK. A tool designed for prying and loosening or compacting earth, rock and other material.

It consists of a tapering, slightly curved, steel bar about 2 ft. long, one end of which is drawn to a long, narrow, pyramidal point and the opposite end to a wedge-shaped edge about ⅞ in. wide. The tool has a

Clay Pick
(See Pages 706, 829 and 832)

large oval eye at the middle, to receive a wooden handle about 3 ft. long. As the working ends of the pick are subject to severe service, they are frequently made of manganese steel with a view to minimizing repairs and prolonging the service life of the tool.

PITCH. A residue obtained from the distillation of tar. Coal tar will usually run about 50 per cent to 60 per cent pitch.

PLOW. An implement drawn by animals or moved by steam or other power and used to cut into the ground several inches, to raise, loosen and turn over the soil in a furrow, pulverizing it so that it may be handled with scrapers, as for ditching cuts or building embankments.

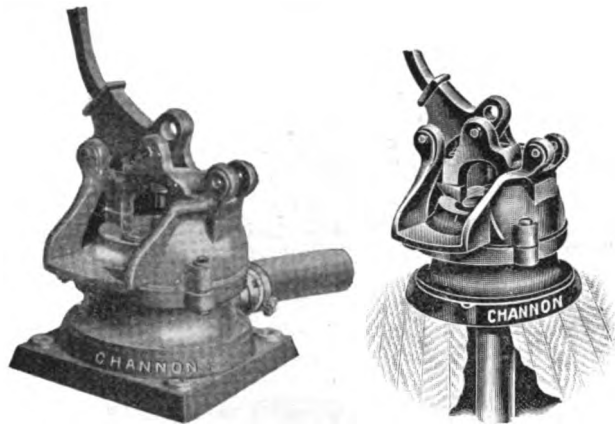
The railway walking plow, of ample strength to plow the ditches in cuts while being drawn behind a cross arm attached to a locomotive, consists essentially of a horizontal steel plow beam provided at the forward end with a clevis for attachment to the locomotive cross arm, the rear end of the beam being held by a frame formed by rods fastened between a pair of inclined handles which extend back, outward and upward from their lower fastening to the central supporting iron mold board, to the base of which is bolted a steel plow share, its concave front cutting edge ending in a projecting slip-point designed to cut into the ground, while a small wheel or drag depending from the forward end of the beam, regulates the depth of the furrow, the line for which is cut by a steel disc set in the plane of the axis of and beneath the beam, in front of the share, which is attached to the beam by means of a standard.

PNEUMATIC. Of or pertaining to air, gases, etc. The term is commonly restricted to the use of compressed air.

PNEUMATIC TOOL. A tool driven by the expansive force of compressed air. Compressed air is used for operating many small tools, such as riveting, metal drilling and wood boring tools used in the fabrication, erection and maintenance of railway bridges and other structures.

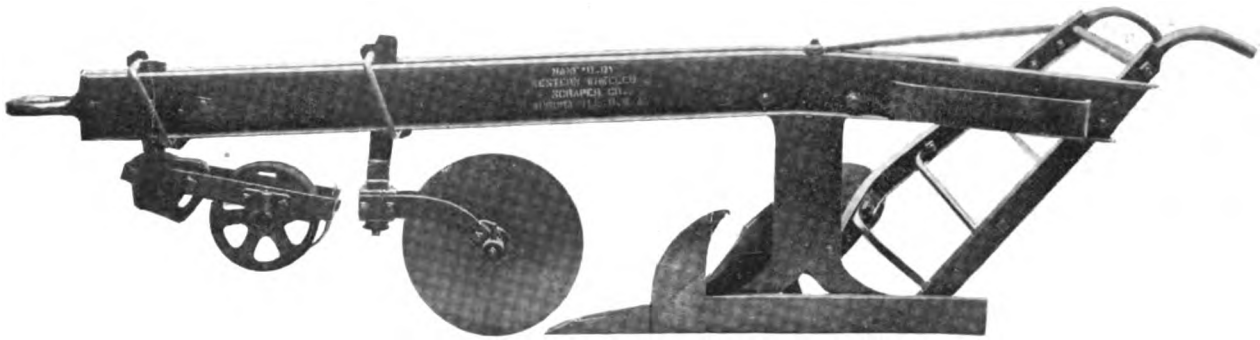
POINTING. Filling of joints or defects in the face of a masonry structure (A. R. E. A.). The mortar may fall away from the face of a masonry wall on account of vibration or disintergration from the effects of frost, etc., usually to a depth equal to the width of the joint or thereabouts. The crevices are cleaned and refilled with fresh mortar to a smooth face finish, the material being pressed home with the point of a trowel.

PUMP, TRENCH. Any portable hand-operated pump used to remove water from a trench, usually during excavation. A type commonly used for this purpose is the diaphragm pump, consisting essentially of a flexible diaphragm or plunger valves operating in a cylindrical steel casing, on the bottom or side of which is fastened a flexible suction tube.



Channon Portable Diaphragm Trench Pumps

PUTTY. A paste of the consistency of dough in general use by glaziers to fix panes of glass in window sashes and by painters to fill nail holes, etc., in wood before painting. After application putty dries and sets, but may show through white paint if it is covered before drying. Putty is made of about 85 per cent whiting (soft carbonate of lime) and 15 per cent raw linseed oil. It is applied with a putty knife which has a blunt flexible trowel like blade. See Whiting.



Western Locomotive Plow
The Western Wheeled Scraper Co.

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R

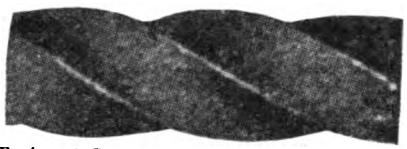
REINFORCING BAR, FOR CONCRETE. A metal bar embedded in concrete to add strength to the structure and thus permit reducing the mass of the concrete.

Corrugated Round Concrete Reinforcing Bar
The Corrugated Bar Co.
(See Page 680)

Corrugated Square Concrete Reinforcing Bar
The Corrugated Bar Co.
(See Page 680)

Reinforcing bars are generally used in any concrete construction. They are especially adapted to railway structures such as foundations, concrete bridges, culverts, culvert pipe, locomotive coaling stations, water tanks, engine terminal and other railway buildings.

Reinforcing bars are usually made of iron or steel according to the service demanded. They are commonly round in section though other sections are often used. They are rolled as straight bars and furnished in specified lengths. They are usually bent, spliced with wire or cut to fit in the forms before the concrete is poured. Reinforcing bars are frequently rerolled from scrap rail in rolling mills located in scrap rail sorting yards.



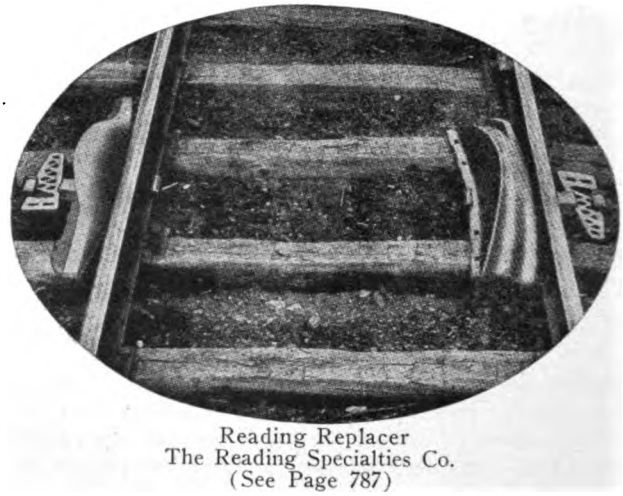
Hot Twisted Souare Concrete Reinforcing Bar
The Franklin Steel Works
(See Page 693)

The Swastika Concrete Reinforcing Bar
The Interstate Iron & Steel Co.
(See Page 693)

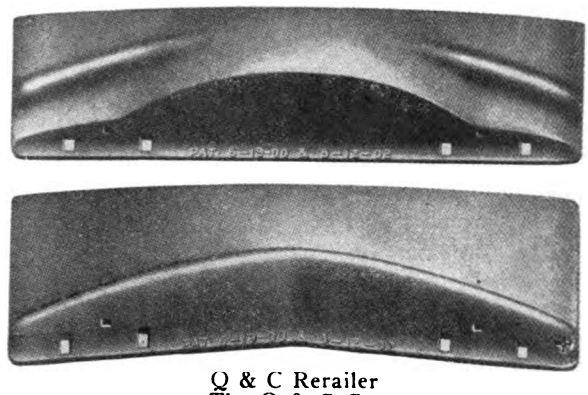
RERAILER. A metal casting designed to be secured to the running rail to guide the wheels of derailed rolling stock on to the track.

Rerailers are commonly made and used in pairs as rights and lefts. The casting is a little higher than the rail and contains a suitable wheel-flange channel inclining toward the top where it terminates, thus serving to shift the wheel tread to the rail after the wheel has mounted and ridden to its summit. While rerailers may be spiked to the ties, a safety clamp at the side or some similar holding device is of great assistance and is generally used. (See Page 693).

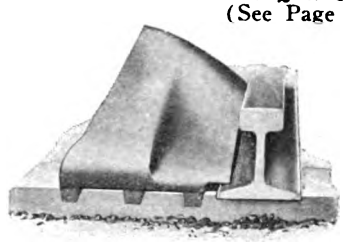
Rerailer
The Buda Co.
(See Page 660)



Reading Replacer
The Reading Specialties Co.
(See Page 787)



Q & C Rerailer
The Q & C Co.
(See Page 776)



Rerailer
The Buda Co.
(See Page 660)

RIGHT-OF-WAY. The land and water rights necessary for the construction and maintenance of the road bed, its foundations and accessories including the property necessarily occupied for railway purposes. The customary right-of-way width is 100 ft., usually 50 ft. on each side of the center line of track, such a strip of land being considered sufficient for the roadway, except where station grounds, heavy earthworks, etc., necessitate extra areas. Lesser widths are used in congested districts especially in cities where streets are frequently vacated for railway use.

ROCK CRUSHER. A rock-breaking machine designed to crush large stones and boulders into particles of suitable sizes for various uses.

The usual types are the gyratory, jaw and disc crushers, so named from the principles on which the machines are operated. The uses of these devices include the breaking of large stone from 36 in. or

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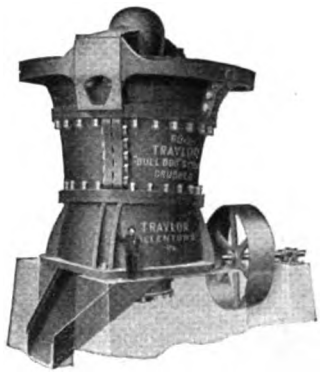
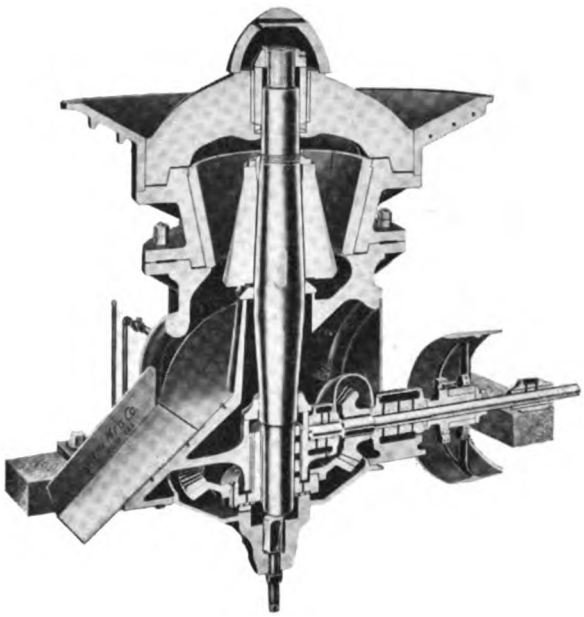
even 60 in. diameter to particles of from 4 in. to 5 in. diameter, and the re-crushing of the latter to the smaller sizes suitable for concrete, ballast, roadways, etc.

The gyratory crusher is designed in several sizes to crush and re-crush rock and boulders for any purpose for which this material is used. It consists essentially of an inverted truncated, convoluted or



Traylor Gyratory Crusher
The Traylor Engineering & Manufacturing Co.

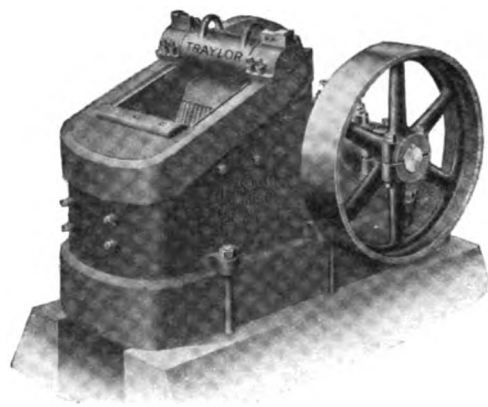


Austin Gyratory Crusher
The Austin Manufacturing Co.

smooth solid steel cone mounted on a vertical shaft or spindle and centered with a hollow conical steel hopper, the top end of the spindle being held in position by means of an arched steel beam or a casting which spans the top shell or rim of the hopper on which its ends bear, while the shaft below the cone is encased in a vertical eccentric. The base or bottom shell supports the machine, provides bottom bearings for the spindle and contains the revolving gear turned by a horizontal counter shaft which is belt-connected to the engine. The bevel gear at the end of the counter shaft engages a main bevel driving gear, encircling the base of the vertical eccentric which sets on a machined seat or bottom bearing. The material is poured into the stationary hopper from above, is crushed by the eccentric rotation of the conical crusher head in the V-shaped space within the hopper and falls through the circular aperture between these parts at the bottom into a delivery spout attached below the base of the crusher which is set on an elevated foundation.

The jaw crusher, also made in several sizes to crush rock for its various uses, is oblong in plan, consisting essentially of a metal frame supporting on opposite walls a horizontal shaft carrying a wide eccentric inside of cylindrical bearings which form the top of a pitman system which depends therefrom and in turn supports the engaging ends of a pair of toggle plates, which, being lifted and lowered by the eccentric movement, operate in tandem to alternately push horizontally against and recede from the back of the lower end of the crusher jaw, which is hinged at the top, and steeply inclined. Its working surface is vertically corrugated and rectangular, and in its inclined position it forms the movable rear wall of a V-shaped hopper of which the fixed front wall is vertical or inclined and does not quite meet the jaw at the bottom. The slight forward and backward movement of the jaw crushes the stone between its lower edge and the face of the front wall of the hopper; the crushed particles being sized by the adjustable bottom opening, through which they fall

Jaw Rock Crusher
The Western Wheeled Scraper Co.



Bulldog Jaw Crusher
Traylor Engineering & Manufacturing Co.

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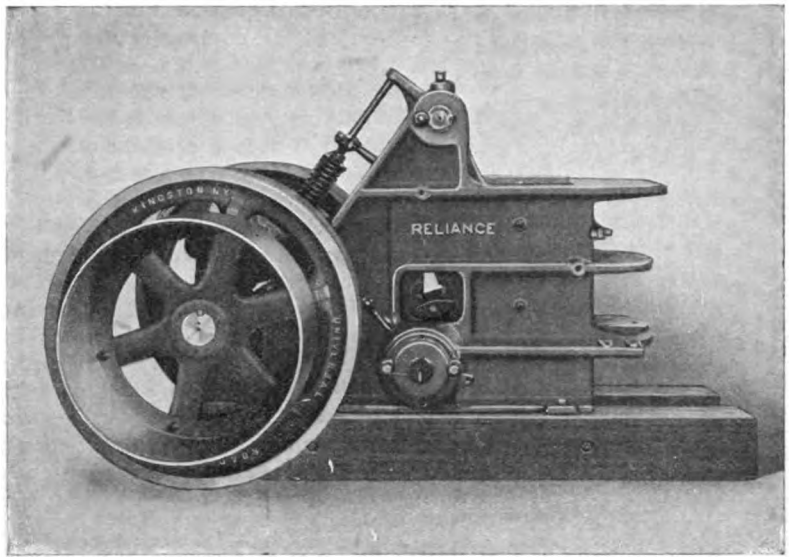
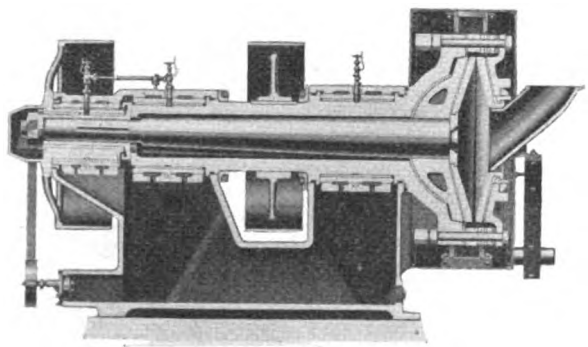


Reliance Jaw Crusher
The Universal Road Machinery Co.

into the delivery spout. In the smaller variety of crusher a single toggle is arranged to move the jaw. The fly wheel, which is belt-connected to the power unit, is attached to the end of the main shaft outside the frame.

The disc rock crusher has two shafts, one containing the other, which hold together at one end two cymbal-shaped, hard metal discs, their adjacent



Symons Disc Crusher
Chalmers & Williams, Inc.

concave faces being close together but not quite parallel, the space between them forming the crushing hopper into which material is fed through a circular metal spout centered in the outer disc. A ball and socket joint of about three fourths the diameter of the discs connects the shafts at the crushing end, allowing the axis of the inner tapered shaft to be set at a slight angle to the outer shaft in a cylindrical chamber. The outer disc is held in a cap secured to the socket end of the outer hollow shaft and is driven by a central wheel, while the inner disc is supported by the ball end of the solid shaft, inclining to rotate with the outer disc when material is being crushed, though it is not positively driven. Both discs rotate in the same direction at equal speed, the crushing being effected by the wavy motion imparted by their relative positions on the shafts whose axes are not quite parallel, while the material is meantime thrown outward toward the edges of the whirling discs by centrifugal force, until the wedging between the converging rims and the pressure from the wave motion crushes and throws the small particles into the delivery spout beneath the hooded crushing head. Disc crushes are specially adapted to re-crushing and turning out fine particles of material.

ROPE. A cord over 1 in. and less than 10 in. in circumference made of (a) hemp or other vegetable fiber or of (b) metallic wires, twisted or braided together. Ropes are generally used to transmit power between parts of machines as well as between power units and the machines they operate and the loads

Three Strand Manila Rope

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Four Strand Manila Rope

moved by the machines; also to directly move or hold loads, or to hold objects together. For example, ropes sometimes called lines are used to connect the boom of a derrick to the mast, to raise and lower the boom, to revolve the derrick and to lift and move the load. Larger vegetable fibre ropes and wire ropes are called cables, the latter being used to resist severe friction and tension, as in drilling machines, locomotive cranes, unloaders, conveyors, pile drivers, hoists, elevator and various other heavy duty machines.

Hemp rope is made from a tall, weed-like plant called hemp grown in temperate and subtropical regions, notably in Manila, in Mexico and in Kentucky. The Manila product is tough and favorably known as hard fibre, as is some obtained from Mexico. Manila ropes usually consist of three or four tightly twisted strands of closely laid fibres and are frequently dipped in preservative and water proofing solutions to increase their durability and resistance to chafing.

Wire rope consists of metallic wires, sometimes galvanized and twisted into strands which are twisted or braided together in much the same manner as vegetable fibre ropes. An advantage of metallic rope is the closeness with which the wires may be laid in the strand and the readiness with which the rope retains its shape and resists abrasion, tension and friction. It has longer service life than Manila rope under many conditions. It will not become soft when wet but is subject to rust unless galvanized or otherwise protected from the weather.

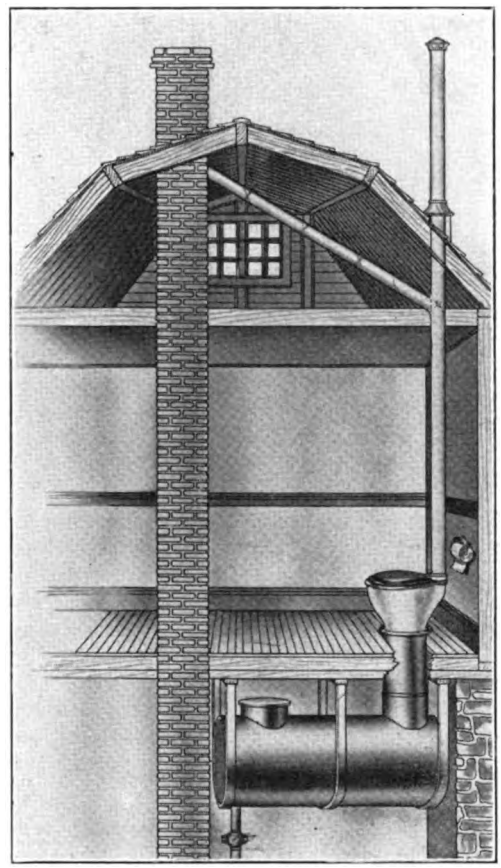
ROPE, RUNNING. A rope designed to resist the tension and friction of movement about the sheaves of tackle blocks, etc., for which service it must be stronger than a standing rope which is made to be used in fixed tension. See Rope, Standing.

ROPE, STANDING. A rope designed to be used in fixed tension only, as distinguished from a rope which moves about the sheaves of tackle blocks, etc. See Rope, Running.

S

SANITATION. The science of the preservation of health, especially by elimination or the counteracting of the effects of germs which cause or accompany and spread impurities in the air, in ground water, sewage, etc.

In the modern acceptance of the term, sanitation is the application of means to eradicate insanitary



Perfection Toilet, showing Tank, Bowl and Ventilator System
The Chemical Toilet Co.
(See Page 662)

methods and the conditions of unhealthfulness resulting therefrom, as the local use of germicides, the installation of surface and underground drainage, sterilization of water supplies and the provision of hygienic lavatories with or without sewage facilities.

The problems of sanitation involve the discovery and application of remedies for the causes of epidemics. While these matters are delegated to proper authorities in towns and cities, outlying districts frequently lack the means to successfully combat unhealthful conditions. The facilities provided must be installed in small isolated units rather than collectively as in the sewage systems of cities.

These small units have their independent sewage disposal systems, either on the basis of sedimentation

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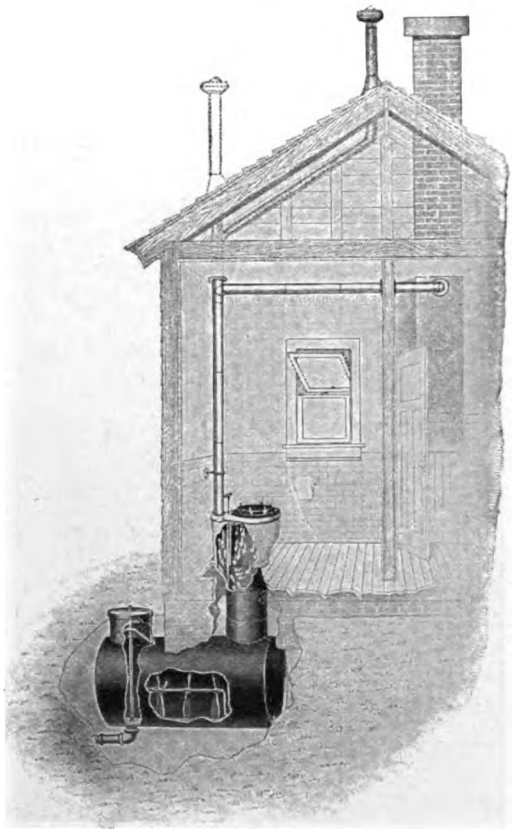


Kaustine Waterless Toilet
Kaustine Company, Inc.
(See Page 730)

and liquefaction in tanks and final evaporation in shallow branching drains or filter beds; or by means of the agitation of antiseptics in the treating tank to thoroughly purify its contents before removal. Ventilation plays an important part in all sanitation including these isolated unit systems. In the first, the nitrogen of the air is the final agency of purification while in the second, high ventilation is employed from the start and an underground leaching system where possible in the last cycle of operation. See Ventilation.

SAW, HAND. A tool with a thin tempered steel blade finely serrated on the working edge with sharp angular teeth and used for cutting wood or metal.

The wood sawing tool commonly used by maintenance forces consists of a toothed steel blade usually

Hand Saw

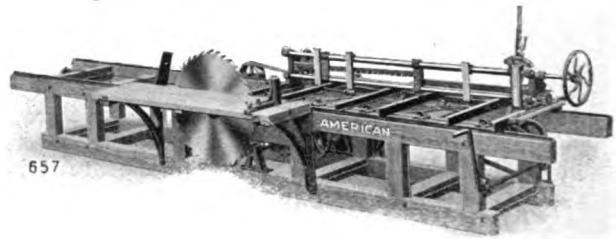
about 2 ft. long, 2½ in. wide at the point and 6½ in. wide at the shoulder, which is held by screw bolts in the split shank of a terminal D-shaped wooden handle. The sawyer grasps the handle loosely to push the blade across and into the work, repeating the stroke with the blade held always in the same plane and at the same angle. This style of saw may have a cutting edge with knife-like teeth so filed and set as to cut across the grain of the wood readily, or it may have teeth that are chisel-like, set nearer in line to rip or saw with the grain of the wood.

The cross-cut saw used by maintenance forces in timbered country has a tempered steel cutting blade averaging from 7 in. to 9 in. wide and from 4 ft. to 8 ft. long, tapering slightly toward each end and serrated with large, slightly convex teeth. To each end of the saw is fastened a straight wooden handle set at right angles to and extending about 12 in. above the blade. This tool, used in felling trees and sawing logs, is operated by two workmen, one at each end.

A hack saw is a tool for hand sawing metal which is sometimes used by trackmen for cutting rails, etc. It consists of a fine, flat, ribbon blade about 12 in. long fastened across the open front end of an adjustable U-frame. In sawing, the frame is held in a vertical plane with the curve to the rear and the blade to the front, while it is raised and lowered by means of a vertical handle attached to the frame immediately below the blade. An advantage of cutting a rail by this method is that the sawed ends are smooth surfaces, whereas a chisel cuts a rail roughly though more quickly. See Rail Saw, (Track Section).

SAWMILL. A power driven plant for sawing timber consisting essentially of a saw moving in a frame with a table to support the timber and an arrangement for feeding it to the saw.

Sawmills are stationary or portable, the more extensive plants being of the stationary types, usually



American "Empire" Bolting Machine
The American Saw Mill Machinery Co.
(See Page 640)

American Short Log and Tie Mill
The American Saw Mill Machinery Co.
(See Page 640)

including various machines for special purposes such as circular saws, band saws, cutoff saws, etc., with the shafting, gears and belts or other power connections required. Portable sawmills are usually limited to such circular saws and power units as are readily transported on cars, the saws being about 1½ times the diameter of the largest log to be cut. The amount of power is not necessarily sufficient to maintain the highest speed in sawing. A large saw with wide spaced teeth may be successfully operated at slow speed with limited power.

Sawmills are operated by some railways to saw new ties and other materials from tracts of company

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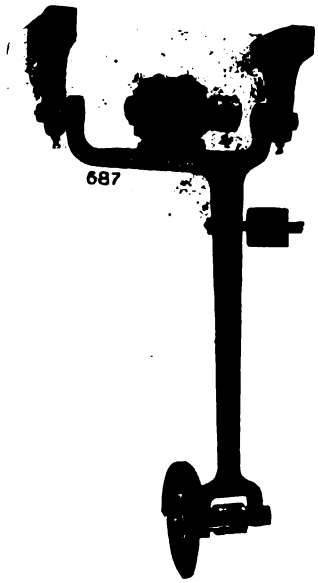
owned timber for company and sometimes for commercial use. The resawing of timber reclaimed from bridges, docks, etc., is appreciated generally by railway companies and widely practised.



American Swing Cutoff Saw
The American Saw Mill Machinery Co.
(See Page 640)

Bridge timber and wooden pile cutoffs frequently are resawed while the wooden bridge or dock is being dismantled, the products secured being usually sheathing, boards, sills, scantling, studding, joists, wedges, blocking posts, concrete form lumber, blocks for wood block floors and any rough lumber stocked or purchased for bridges and buildings, fences, etc. Many bridge timbers are disused only on account of decayed ends, the cutoff stick being serviceable for further bridge work. It is usual in extensive building projects to erect portable sawmills temporarily on the site of the work for such resawing.

In some cases reclaimed timber is collected at a central point as at division headquarters for resawing at permanently established saw mills where supervision and power are readily available and the finished stock may be piled without rehandling.

SCRAPER. A scoop, usually of steel used to move loose earth, etc., as in railway grading and foundation excavations. It is commonly hauled by horses, though in some cases by cable. The load is obtained by forcing the open mouth into and through the material; and it is dumped by tipping the pan forward with the mouth down. Scrapers are either of the drag type or of the style which has a pan swung under an axle between a pair of wheels, known as drag and wheeled scrapers respectively. The former is of about 5 cu. ft. capacity and is used where the haul is short as from railway borrow pits to adjacent embankments 6 ft. or less in height; while wheel scrapers are used for more extensive work and longer hauls economically limited by their capacities of 7 to 16 cu. ft. See Scraper, Drag. Also Scraper, Wheeled.

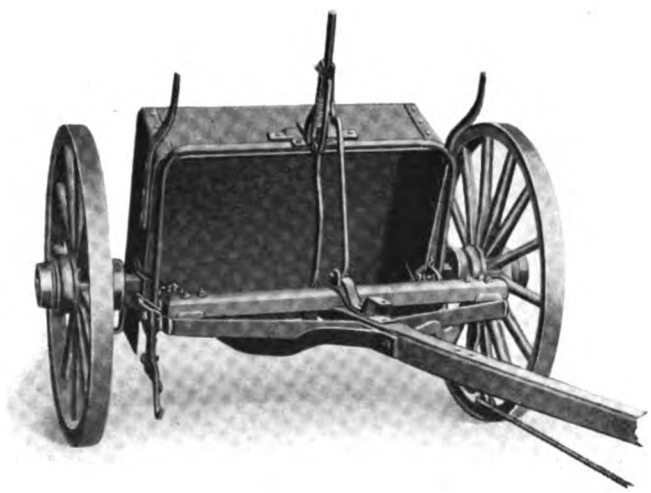
SCRAPER, DRAG. A scraper with a revolving arched steel bale with a ring at the middle or some similar contrivance by which it may be drawn, while at the rear and extending backward are fastened a handle and latch or two parallel handles to guide the device which when upright slides along the ground on its base, which is usually shod with one or more steel wearing strips or shoes. The scraper handles

Drag Scraper

Round Back Drag Scraper

are lifted slightly as its edge is forced forward into the plowed or loose earth and then dropped on obtaining the load, while the driver, walking between the handles, dumps the load by lifting the handles high and forcing the front edge of the scraper sharply into the ground when it will turn bottom uppermost with the handles forward in the normal unloaded position. The scoop, usually 3 ft. or less in length, 2 ft. 6 in. wide with sides 10 in. high at the back and sloping forward, has a capacity of 5 cu. ft. or less. See Scraper.

SCRAPER, WHEELED. A two-wheeled, horse drawn, earth moving vehicle so designed that the pan, depending from the high arched axle and provided with an elevating framework operated by means of levers, latches, etc., can be lowered to the ground while being filled or raised a few inches and latched to clear the ground while transporting the load. In the loaded position the floor of the pan tips backward slightly from the horizontal, while the



Wheeled Scraper

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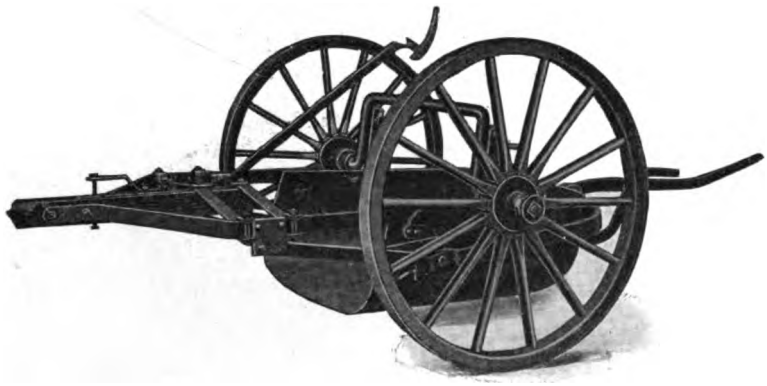
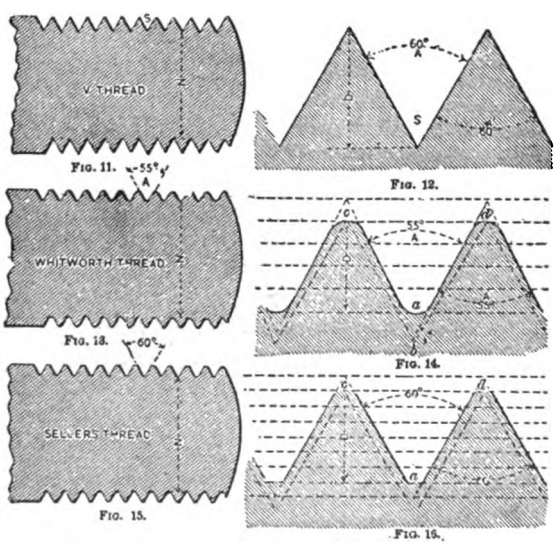
load is discharged by tilting the pan forward about 95 deg. and releasing the latch, in which position it is secured while empty by means of a front lever latch. The pan of a wheel scraper of 9 cu. ft. capacity is about 3 ft. square and 12 in. deep, mounted on a 1⅜ in. by 1⅜ in. axle between wooden wheels 38 in. high with 2½ in. tires. The wooden tongue, similar to a wagon tongue, is fitted at the back with a cross bar bolted to steel truss bars which are pivoted to the sides of the pan at the top forward corners. The lowering device is readily adaptable to holding the pan at the required scraping depth while loading, which usually requires one to two men. When possible, embankments are built up with wheel scrapers in level layers not exceeding 6 ft. high, thus providing convenient roadways for the scrapers and insuring thorough compacting of the materials.



Wheeled Scraper

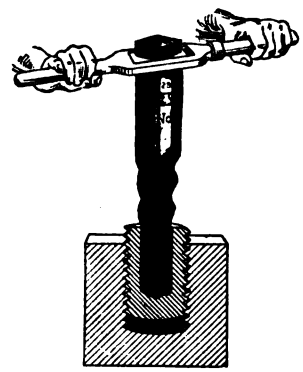
SCREW. A cylinder surrounded by a spiral ridge or groove, every part of which forms an equal angle with the axis of the cylinder, so that if developed on a plane surface it would be an inclined plane. The screw is considered as one of the mechanical powers. When used alone the term commonly means a wood screw, having a slotted head and gimlet point, for driving in with a screw driver. Machine screws are similar, except that they have no gimlet point and have a metal screw thread. They are used for uniting metallic parts. All ordinary forms of bolts have screw threads cut on them, but are not commonly called screws. See Screw Thread.



Screw Threads

SCREW EXTRACTOR. A small metal pin expressly designed to remove broken set screws and cap-screws, stay bolts, etc.

A screw extractor commonly consists of a short cylindrical steel shaft, the working portion of which is tapered and spirally threaded, while the operating end has a square head to receive a tap wrench. The broken screw or bolt is first drilled and the screw-extractor is then inserted into the drilled hole, the left hand spiral threads gripping the sides of the screw as the tap wrench is twisted to back it out. A screw extractor should be of proper diameter to bore into the metal without bulging it at the sides. A set consists of one handle and several bits of various sizes.



Ezy-out Screw Extractor
The Cleveland Twist Drill Co.

SCREW GAGE. An instrument for measuring the diameters or sizes of screws. Gages are of two kinds, external, for measuring male screws, and internal, for measuring female screws.

SCREW PITCH GAGE. A gage for determining the number of threads to the inch on screws. It consists of a number of toothed plates turning on a common pivot, so that the serrated edge of each may be applied to the screw until one is found which corresponds therewith. The figures stamped on the plate indicate the pitch and the number of threads to the inch for the ordinary single thread screw.

SCREW THREAD. The groove, or the material between the grooves, which is cut on the outside surface of a cylinder to form a male screw, or on the inside surface to form a female screw. Screw threads for pipe are usually V-shaped, but all other threads in common use conform to the United States standard.

SCREW THREAD, U. S. STANDARD. A 60-deg., rounded V-shaped thread with bearing surfaces at right angles to the axis of the bolt or the aperture of the nut. The angles between the ridges and grooves are uniformly 60 deg., while the rounded contour of the section conforms to a removal of ⅛ the height and a filling in to ⅛ the depth of a sharp 60-deg. thread.

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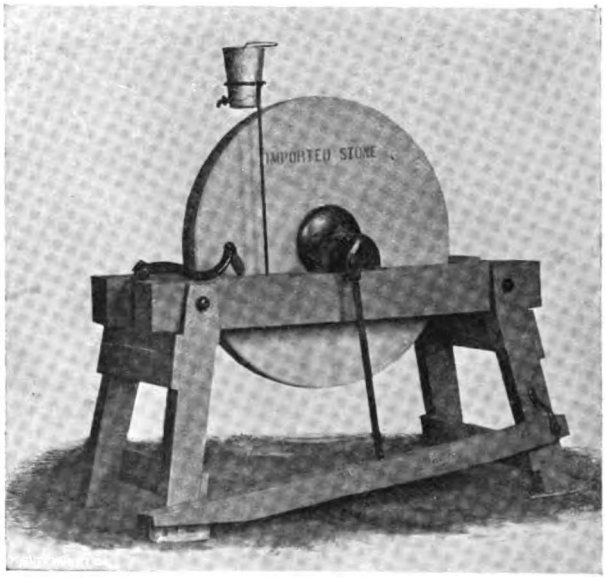
Screw threads for pipe are usually V-shaped but all other threads in common use conform to the rounded U. S. standard, including those cut on screws, bolts and nuts. See Bolt. Also Bolt, Track, (Track Section). Also Screw Thread.

SEGREGATION, STEEL. The tendency toward separation of the constituents during the cooling of the molten metal in the manufacture of steel, which is a mixture composed of several different elements, most of which have different melting points. Therefore in solidifying from the molten condition these elements do not always solidify at the same time. Consequently some of the elements, particularly carbon, phosphorus and sulphur which have low melting points, seek the position in the mass where they can longest remain liquid. This produces a central zone in the top-central part of the ingot that is almost invariably richer in these elements than the rest of the metal. Many devices are employed to overcome segregation, which is especially harmful to rails, causing a hard central zone while the periphery of the section is softer metal. See Rail Failure, (Track Section).

SHAKE. A separation of the wood fiber, due to the action of the wind. Shaken timber usually parts along the lines of the annual growth rings or at the line between the dry, dense heart wood and the greener sapwood or both, on account of the bending of the tree under the influence of high wind which severely strains the fiber and causes it to part along these lines of natural cleavage. See Tie, Cross, (Track Section).

SHARPENER. Any device designed to whet the edge or point of the working end of a tool.

Natural slate and sandstone, artificial stones and roughened steel are the materials commonly used for sharpeners, though any other substances hard

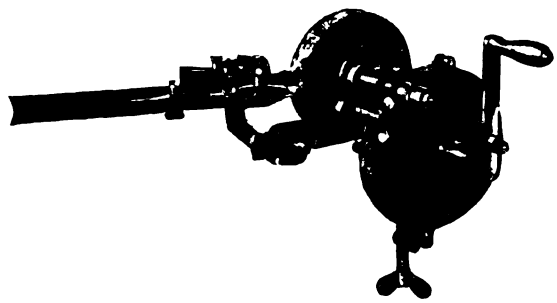


Hand Power Grindstone
The Mitchell Grindstone Works

enough to suitably abrade the converging surfaces may be used to restore the keenness of the edge or point of a tool. They are operated by filing, rubbing or grinding, either by hand or by means of portable or shop power machines. Files and whetstones are the common hand types, while grindstones and arti-

Power Grindstone
The Mitchell Grindstone Works

R. W. Cycle Ball-Bearing Grindstone
The Richards-Wilcox Manufacturing Co.



Tool Grinder
The Buda Co.
(See Page 659)

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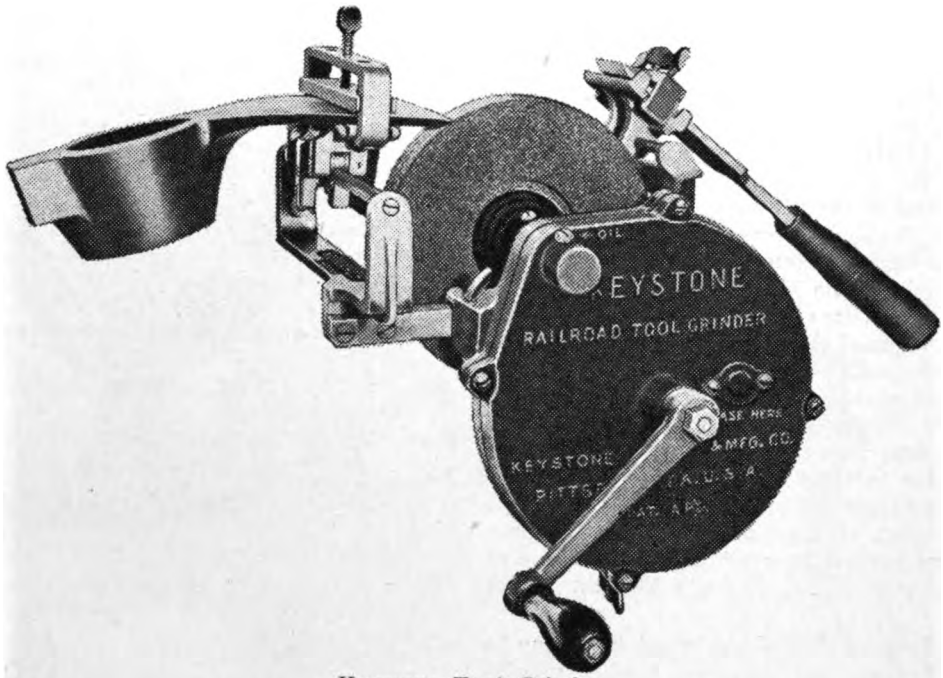
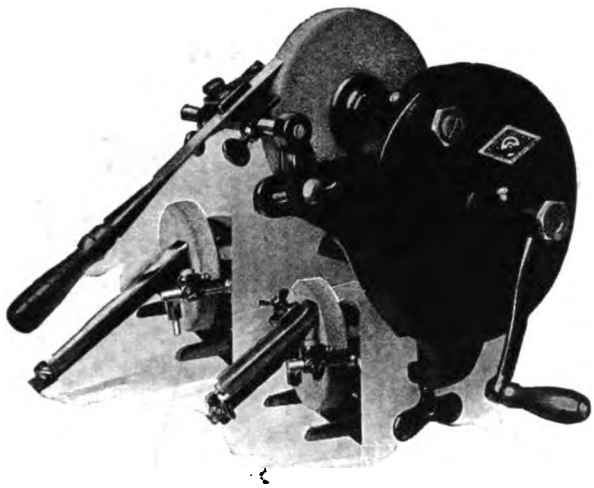
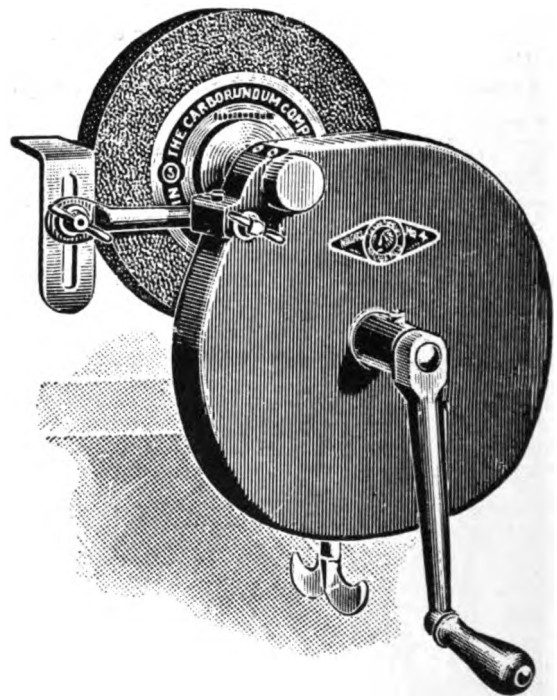


Keystone Tool Grinder
The Keystone Manufacturing Co.



Luther Tool Grinder
The Luther Grinder Manufacturing Co.



Niagara Tool Grinder
The Carborundum Co.

ficial stone tool grinders are portable machine devices, and shop grinding equipment includes power grindstones, emery wheels and artificial stone grinders, the shape, material and operation of a sharpener being made to suit the uses for which it is designed. Filing is done with a small rod of roughened steel, while a scythe blade is ordinarily whetted with dry slate stone and carpenters tools are usually sharpened by applying their blades to a stationary grind stone or oil stone.

Files are made in many forms, the usual shapes being rods that are round, quarter round, flat or triangular in section with various tapers and modifications. The fine parallel ridges of steel on their filing surfaces may be crossed with other similar series or the ridges may be replaced with pyramidal points, as in a rasp. A file is fine or coarse as the ridges are close and shallow or deep and far apart.

A grindstone is a solid disc of sandstone mounted on an axle and revolved like a wheel while its circular face is wetted and used as a grinding surface. A grindstone is coarse and quick cutting or fine and slow cutting, according to the texture of the stone.

Tool grinders of artificial stone include small discs, wheels, cones and such other shapes as are suitable for the tools. The small portable sharpeners such as files, whetstones and artificial stone grinding ma-

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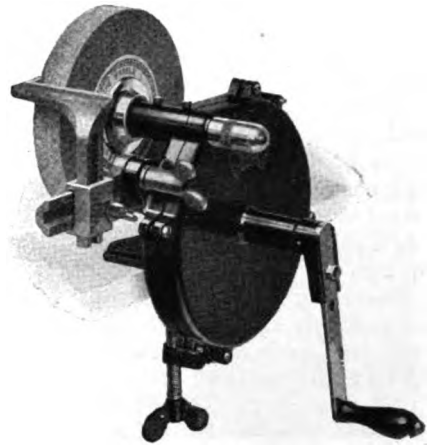

American Liberty Tool Grinder
The American Grinder Manufacturing Co.

chines are especially adapted to whetting tools, such as scythes, axes, adzes, etc., used along the line of a railway where water is not always available.

All sharpeners are worn, dulled and smoothed by repeated use. Files may be roughened by immersion in acid, but are preferably sharpened by means of machine tooling to refurrow the steel. Whetstones and grindstones which are worn smooth and out of true, may be reshaped and roughened by abrading with harder stones or steel. Artificial stones are commonly furnished with toothed hard steel shapers to restore the grinding surfaces to proper form by friction.

SHARPENER (Grindstone). A solid wheel of sandstone for grinding and sharpening tools, commonly mounted on a central spindle and turned by means of a crank handle or foot tread.

The grindstone in common use is about 2½ in. thick and 24 in. in diameter and is supported between the sides of a wooden or steel frame across the top of which the steel spindle or axle revolves in sockets or boxings which set on the sides of the frame. This implement complete weighs about 100 lb., although heavier and larger stones are frequently used in shops where they are operated by machine power.

SHARPENER (Tool Grinder). A portable revolving grinder with tool-holding abrasive attachments for sharpening maintenance tools, designed to be clamped on any fixed base such as a block, a bench or the deck of a hand car. It consists commonly of an artificial stone wheel about 1 in. thick and 7 in. in diameter mounted on a spindle rotated by means of gears enclosed in a metallic dust-proof housing, the crank handle being turned by hand or foot power. This implement, usually supplied with tool holders and separate grinding wheels, cones, etc., weighs about 35 lb., requires no water, cuts quickly, is light running and speedy, and is coming into general use for railway maintenance gangs.

SHIM. A bearing piece, usually of wood or metal, inserted between surfaces to bring a part of any construction to the exact desired positions; for example: a thin wood block placed on a foundation beneath a sill to level a building floor, or between a cross tie and the base of a rail to surface a track in winter; a steel spacing piece inserted between rail ends when laid to provide allowance for the expansion of the steel due to changes in temperature; or a steel plate placed on a pier under the bearing plate of a bridge span to raise and bring the member in surface with others. The term is used broadly to describe any spacer used thus to improve the position of parts. See Shim, Track, (Track Section).

SLAG. The cinder resulting from the heating of ore and metal when treated in a furnace, especially for making pig iron or steel. Slag, being lighter than the molten metal, rises to the top and is tapped away separately. It is usually glassy and brittle and is frequently crushed for ballast. See Iron. Also Steel. Also Ballast, (Track Section).

SLEDGE. A beating and striking tool, consisting usually of a double-faced steel head, 4 in. to 6 in. long, with circular ends about 2½ in. in diameter. The end of a straight wooden handle

Blacksmith's Straight Pien and Cross Pien Sledges

about 2 ft. 6 in. long is wedged in a central oval eye, while the broad faces afford ample surfaces to strike a fair and heavy blow with a full two-armed swing of the tool which commonly weighs about 5 lb. to 15 lb. according to the service for which it is designed. See Hammer.

SOLDER. To join pieces or parts of a metal with a melted binder metal which, having a low melting point, does not fuse with but adheres to the metal operated on. The binder metal is also commonly known as solder.

SPADE. An implement for cutting and digging into the earth.

This tool differs from a shovel, which it closely resembles, in that its rounded or square-ended blade is flatter and does not turn up at the edges, being thus more suitable for cutting the soil than for throwing it to a distance when loosened. The blade, usually 5½ in. wide by 14 in. to 22 in. long, is cast with or riveted to a ferrule or handle socket which holds a stout wooden handle terminating in a D-shaped hand-hold. The tool is commonly about 3 ft. 6 in. long over all, though drainage spades used in digging deep narrow trenches having tapering concave round-pointed blades are somewhat longer.

SPIEGEL. See Spiegeleisen.

SPIEGELEISEN. An alloy of not over 30 per cent manganese, the balance being mostly iron. It is sometimes called spiegel and is much used in making steels of all kinds, either spiegel or ferro-manganese being practically the only means of supplying manganese to the steel. See Ferro-Manganese.

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REPAIR TOOLS

1 Blacksmith Forge with Anvil and complete tools.	2 Clawbars
1 Small Bench Vise	1 Siphon, complete
3 Pipe Wrenches, assorted sizes	1 Axe
3 Monkey Wrenches, assorted sizes	1 Hand Saw
6 Stilson Wrenches, assorted sizes	1 Set Triple Blocks with Rope
1 Ratchet, with assorted Twist Drills	2 Lining Bars
6 Round Files, assorted sizes	1 Pinch Bar
1 Hacksaw, with twelve blades	6 Shovels
1 Set Pipe Taps and Dies	6 Picks
1 Set Bolt Taps and Dies	1 Coal Scoop
6 Cold Chisels, assorted sizes	1 Flue Cleaner
2 Machinists' Hammers	1 Fire Hoe
2 Sledges	1 Clinker Hook
2 Switch Chains	1 Slash Bar
2 Re-railing Frogs	2 Hand Lanterns
2 Ball-Bearing Jacks	2 Torches
2 Spike Mauls	1 Track Gage
	4 Rail Clamps
	Assortment of Packing
	Assorted Oil, in cans

STEEL. A metallic substance consisting chiefly of the element iron combined with other metallic and non-metallic elements by melting and which becomes (after solidifying) easily malleable and fit for rolling or forging into shapes. The amounts of the various elements constituting the mixture, which can be regulated almost at will, qualify the resulting steel for the particular use for which it is intended. Thus low, medium and high carbon steels mean respectively those mixtures containing a relatively low, medium or high percentage of the element carbon.

Steel is mostly made from pig iron, to which ferrous-scrap of various kinds is frequently added. Steel invariably contains less carbon, phosphorus, silicon and manganese than pig iron and it is therefore essential so to treat the raw materials used for steel making as to cause marked decreases in the amounts of these elements. The various processes by which steel is made depend entirely on chemical reactions induced in the mixture of raw materials by heat and generally by some other agent. The chemical process of steel making is almost invariably one of oxidation; that is, the excessive amounts of the unnecessary and undesirable elements are removed by making them combine with oxygen derived from the air or from some other source, such as limestone and iron ore. Four important processes are employed in the manufacture of steel, (1) Bessemer, (2) open hearth, (3) crucible and (4) electric, while in addition a combination of two processes is frequently resorted to in order that time may be saved and production increased. For example, the duplex process is a combination of the Bessemer and open hearth processes.

Bessemer Process

The Bessemer process consists essentially of blowing air through molten pig iron in an egg-shaped vessel called a converter. The oxygen of the air oxidizes the carbon, manganese and silicon of the iron, causing them either to pass into the atmosphere or form a slag which is easily removable. The converter, which may hold as much as 25 tons of metal, is completely lined with fire brick and is mounted on trunnions across its narrow axis. A false fire-brick bottom, perforated with small holes, is in the lower part of the vessel when it is in an upright or "blowing" position, so that air under a slight pressure introduced through one of the trunnions can be blown through them. Molten pig iron is charged into the vessel while it is lying on its side, after which the air blast is turned on and the vessel is tilted to an upright position, terrific boiling of the molten pig iron taking place, with the result that after a period of 10 to 20 minutes the character of the flame which comes from the upper open end of the vessel indicates that the carbon has been sufficiently oxidized or burned out, while the silicon and manganese have previously been formed into a slag. The vessel is then turned down and the blast cut off, following which the metal is poured into the teeming or casting ladle, pains being taken at this juncture to make such addition of molten alloys to the metal as will insure the proper grade of steel. In the Bessemer process, as generally conducted, there is no effect on the amounts of sulphur and phosphorus originally existing in the pig iron used.

Open Hearth Process

Desirable diminution in the amount of phosphorus, and frequently of sulphur contained in the raw materials available for making steel, and which cannot be obtained by the Bessemer process, can be produced by the open hearth process. This method obviously permits the use of a much greater range of quality in the selection of pig iron and scrap employed for the original change. For this reason, coupled with the comparative ease with which a desired chemical composition can be attained, the production of steel by the open hearth process has advanced rapidly.

The open hearth furnace consists essentially of a platter-shaped hearth built of fire bricks and covered with an arched brick roof. The furnace is so arranged that gas or oil may be introduced with air through ports at the ends of the platter beneath the roof. The charge is placed on the hearth through doors on the side opposite the tap hole. The air used is preheated by passing through two sets of checker work built of fire brick and so arranged that the gases passing out of the furnace through the discharge port heat the checker work of that side to a high temperature prior to passing out through the high stack. Intermittently the direction of the current or air is reversed so that cold air is drawn through the previously heated checker work to the entering port, where it is mixed with gas or oil and being then at a high temperature, an intense combustion occurs over the charge of the hearth, which consists of pig iron often mixed with scrap or sometimes of scrap alone, a quantity of limestone also being added. The intense flame soon melts the charge, while the chemical reactions taking place under the high temperatures bring it eventually to a boiling condition. Iron ore is sometimes thrown into the furnace, chiefly for the purpose of oxidizing the excessive carbon of the bath, as the melted charge is called. A heavy slag forms on the surface of the bath, consisting mostly of limestone products, which are primarily responsible for taking up, and thus decreasing the phosphorus and sulphur content of the charge. Frequent tests are taken by the operator dipping into the bath with a small ladle and when its proper condition is obtained the tap hole is opened and the contents of the furnace allowed to run off into a ladle, from which the metal is subsequently cast into ingots. Almost any desired composition of metal can be obtained by

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adding various alloys to the metal at the time it is being tapped into the ladle. Open hearth furnaces produce various amounts of steel at one operation, as much as 100 tons frequently being tapped from a furnace. Each charge or tap is called a "melt" or "heat" as in the Bessemer process.

Crucible Process

High grades of steel to be used for certain tools or fine instruments are often made by the crucible process. This consists chiefly of melting 75 to 200 lb. of metal in pots made of clay to which graphite is frequently added. Careful selection of the small charges and control of the melting results in the production of steels of high quality practically free from evidence of slag and other impurities, while additions of various elements such as chromium, tungsten, etc., may be made with exceptional ease and beneficial results.

Electric Process

Steel may be produced in a furnace so constructed that the necessary heat is derived from electricity. The common types of electrical furnaces depend almost entirely on the arc created between different electrodes used for supplying the heat to melt and refine the charge. The construction and operation of electric furnaces are such as to render control of the economical composition easy and the steel of high quality, comparable in many instances with crucible steel.

Regarding the chemical composition of the steel which chiefly determines its quality, the presence of certain elements, particularly phosphorus and sulphur, may be regarded as destructive, while other elements are essential and desirable. Phosphorus tends to make the steel brittle or "cold short" at atmospheric temperatures, while sulphur has the opposite effect and tends to make it brittle at the higher temperatures so that cracks and flaws may be produced while it is being worked in the rolling mill. It is difficult to say what limits should be placed and not exceeded on the amount of phosphorus or sulphur permissible. Common practice invariably prescribes that phosphorus in open hearth steel shall not exceed 0.04 per cent and in Bessemer steel 0.10 per cent. Sulphur being more injurious as a rule to the manufacturer than to the user of the steel, the permissible percentage is seldom specified. Various gaseous impurities are common to steel, among which may be mentioned nitrogen, hydrogen and oxygen. Their presence may be regarded almost entirely as a necessary evil and present-day practice renders it impossible to limit the amounts permissible.

The useful chemical elements in steel besides iron are carbon, manganese and silicon. In various steels to be used for special purposes, additions of nickel, chromium, tungsten, titanium, vanadium, etc., may be made for the ultimate purpose of creating some especially desirable physical characteristic; as great hardness or high elastic limit. Carbon may be considered the most important factor in steel, for in making steel the amount of carbon is so readily controlled that it becomes the easiest method of obtaining the physical properties desired. In Bessemer rail steel the amount of carbon present may vary from 0.35 per cent to 0.50 per cent, while in open hearth rail steel, on account of decreasing the phosphorus content, the carbon may be safely increased so that the range of limits is between 0.55 per cent and 0.80 per cent. Increasing the carbon in steel increases its hardness and liability to brittleness, while lesser amounts of carbon make softer grades of steel, the physical properties of which resemble those of wrought iron.

Manganese is an important constituent, because when added to the molten metal it combines with any excess oxygen present in the bath and thus greatly assists in purifying the steel. It exists in most steel in amounts up to 1.20 per cent and in addition its chemical effect it somewhat increases the ductility of the metal and makes it roll or work better in shaping. Manganese is generally added in the form of ferro-manganese or spiegelism. When the content of manganese in the steel is increased from 10 per cent to 14 per cent the metal becomes exceedingly hard and tough after quenching in water from a temperature of about 1600 deg. F. and this grade is called manganese steel, which is especially useful in the manufacture of frogs for service in tracks where traffic conditions are severe.

Silicon is added to steel principally for the purpose of eliminating the gaseous impurities and making it dense. Its use up to 0.35 per cent is permissible, but in many cases special steels containing higher amounts are made for various uses.

Good steel depends on many factors, chief among which are its treatment during the time of casting, heating and rolling the ingots into the final shapes. Special provision is often made to insure freedom from piping and segregation in the ingots, while certain precautions and arrangements for heating and rolling the ingots result in improved physical properties. (See Page 650).

STEEL (Alloy). A steel containing some element or elements other than iron and carbon, such as manganese, nickel, chromium, tungsten, etc., in percentages sufficient to modify substantially the useful properties of the metal. These elements are used to produce alloys which especially increase the hardness and toughness of the steel.

STEEL, BORON. A steel which has been treated with a boron preparation for the purpose of deoxidizing the metal.

Boron is a chemical known to be a powerful deoxidizer and scavenger of steel, removing impurities not eliminated by other means. (See Page 650).

STEEL (Carbon). A steel which derives its physical characteristics and properties mostly from the customary mixture of iron, carbon, phosphorus, silicon and sulphur. Such steels may be termed natural steels as distinguished from alloy or special steels which owe their distinctive properties to other elements.

STEEL (Chrome-Tungsten). An alloy steel which contains from 9 to 20 per cent of tungsten and from 2.25 to 7 per cent of chromium, with a small percentage of manganese. Steels containing both chromium and tungsten are in the high-speed class, having the valuable property of "red hardness," that is, they retain their hardness even when red hot, which is a valuable quality in rapidly driven drills or other machine tools.

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STEEL (Chromium). An alloy steel containing from 0.75 to 3 per cent of chromium and from 0.40 to 1.5 per cent of carbon. This metal when properly heat treated, combines intense hardness with a high elastic limit and is especially adapted to withstand violent shocks. It is used in the manufacture of rock-crushing and other machinery for heavy duty lifting jacks, etc. It is highly resistant to impact stresses, oxidation and corrosion.

STEEL, CRITICAL TEMPERATURE. The point or points at which the process of heating steel is retarded. When the metal is heated in a furnace its rise in temperature is not entirely uniform, because it suffers delay at certain stages, while the opposite effect occurs during cooling. The points at which the change in temperature lags for a brief interval of time are called the critical points of steel. In the majority of steels there are three critical points, but because of the composition of some kinds these three points may be combined so that in certain steels there may be only one and in other steels two critical points. The critical temperature is also that at which steel loses its magnetic properties.

STEEL CONVERTER. A pear-shaped steel shell lined with suitable fire brick and mounted at the middle on trunnions so that it can be tilted at various angles to be filled or emptied of metal, used in the Bessemer process of making steel. See Steel.

STEEL (Crucible). A hard steel made in a pot of clay, or of clay and graphite, usually designed to hold from about 75 lb. to 200 lb. of metal. The materials used are usually impure wrought-iron and low-carbon or blister steel with carbon and a flux. Special tool steels are made by this process. See Steel.

STEEL (Duplex Process). A combination of the Bessemer and open hearth processes of steel making to obtain the benefits peculiar to each. In steel made by the Bessemer process the content of phosphorus and sulphur is not affected. It has been found desirable, in many cases, to oxidize the silicon, manganese and carbon of the pig iron in a Bessemer converter, then heat the resultant mixture in an open hearth furnace, where the phosphorus and sulphur content may be reduced materially. This process of utilizing both the Bessemer and the open hearth processes for making steel is called the duplex process.

STEEL (Ferro-Manganese). An alloy of at least 30 per cent manganese, the balance of which is chiefly iron. Eighty per cent ferro-manganese is commonly used, meaning that 80 per cent of the mixture is manganese. The alloy is much used in steel making. See Spiegeleisen.

STEEL INGOT MOLD. A box-like container made of cast iron, open at both ends, and which, when resting with one open end on a base plate or stool, provides an open top mold in which molten steel solidifies after being poured from the ladle. Molds may be from 12 in. to 36 in, square in section, with outside walls several inches thick. They are generally from 4 to 8 ft. long. After the molten steel has solidified in the molds a machine called a "stripper" lifts the mold vertically off of the ingot. See Steel.

STEEL LADLE. A large brick lined pot of riveted steel plates, having at its base a discharge nozzle and a stopper, and designed to hold molten steel tapped into it from the furnace, whence it is poured into the ingot molds by removal of the stopper. See Steel.

STEEL (Manganese). An alloy steel, often known as Hadfield's steel, which contains generally from 11 per cent to 14 per cent of manganese and from 0.50 per cent to 1.30 per cent of carbon. After casting into molds or being rolled into shapes it is immediately quenched in water from a temperature of about 1600 deg. F., when it becomes remarkably hard but it possesses a somewhat low elastic limit. It is one of the few steels that is non-magnetic. It is frequently used on heavy pieces subjected to abrasion, as for grab bucket and dipper lips, manganese steel frogs, crossings, switch points and drawbridge rail locks. These may be made of manganese steel castings or built up from small manganese castings in combination with carbon steel, although sometimes rolled manganese steel is employed. Rolled manganese steel rails have given good service in numerous cases where curve wear is heavy. (See Page 636).

STEEL (Mayari). A natural alloy steel produced from ore imported from Cuba which contains a small amount of natural chromium and nickel, so that these elements do not have to be added to the steel after having been made by the usual process. See Steel, Nickel-Chromium.

STEEL (Nickel). An alloy steel which usually contains from 3 to 3½ per cent of nickel and from 0.2 to 0.4 per cent of carbon. It combines great tensile strength and hardness with a high elastic limit and ductility. It is used in bridge construction, valves, shafts, etc., and particularly in long span bridges for which purpose it is sometimes heat treated and water quenched. Its use saves some weight, which is of importance in such structures. The field for simple nickel steel is restricted because of the comparative cheapness of nickel-chrome steel which serves the same purposes and is not so difficult to roll successfully. Nickel steel frequently has dark seams and surface defects after rolling, which further restricts its use.

STEEL (Nickel-Chromium). An alloy steel containing varying percentages of the elements nickel and chromium, important as a structural metal and ordinarily used in a heat treated state, for automobiles, armor plate and projectiles. Rails made of this alloy steel by the Bessemer process and not heat treated are said to have been unsatisfactory. Iron ore carrying nickel and chromium in percentages sufficient to produce crude iron with 2½ to 3 per cent chromium and 1.3 to 1.5 per cent nickel is mined at Mayari, Cuba. The chromium from this iron is largely lost by oxidation, but nearly all its nickel is retained in the steel. Open hearth steel made partly from Mayari iron is giving good service in rails and track bolts, and the field for this variety of the metal is said to be increasing. Steels containing from 0.75 to 1.5 per cent chromium and from 2 to 6 per cent nickel are used in tools, gears and parts of machinery where resistance to shock or impact stress and abrasion are especially required.

STEEL (Open-Hearth Process). The reduction of pig iron and steel scrap to steel in a shallow.

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rectangular, arch-roofed basin by means of gas flames directed by drafts of air above the basin. See Steel.

STEEL SLAG. The cinder produced in the molten state during the manufacture of iron and steel by the chemical reactions taking place in the furnace. It may be regarded as the waste product of the furnaces but after solidification has many uses; as for ballast, cement making and concrete aggregate. As slag is lighter than the iron or steel it rises to the top of the mass and is easily separated from the product. See Iron. Also Cement. Also Steel. Also Ballast, (Track Section).

STEEL (Special). A steel containing some element or elements other than carbon in such quantity as to give come particularly desirable property to the metal, either with or without heat treatment. A number of special steels are made by the usual processes but more especially by the open hearth, crucible or electric process. Among the more common special steels may be mentioned the following, the composition of each being shown for comparative purposes:

Per cent	Nickel Steel	Nickel Chromium Steel	Chromium Steel	Chromium Vanadium Steel	Silico Manganese Steel
Carbon range	0.10-0.45	0.15-0.55	0.15-1.30	0.15-1.05	0.45-0.65
Manganese range	0.50-0.80	0.30-0.80	0.20-0.45	0.20-0.80	0.50-0.80
Phosphorus, not over	0.04	0.04	0.04	0.04	0.045
Sulphur, not over	0.045	0.045	0.04	0.04	0.045
Nickel range	3.25-3.75	1.0-3.75	....	....	.....
Chromium range	.....	0.45-1.75	0.65-1.30	0.80-1.10	.....
Vanadium, not under	.....	....	....	0.15	.....
Silicon range	.....	....	....	....	1.50-2.10

The above mentioned steels are commonly used for locomotive and motor engine parts, gun forgings and machine tools, while some are used for track devices, long bridge members, etc. A great variety of special steels containing other rare elements like tungsten and molybdenum, are made for special uses, such as high-speed tools, parts subjected to shock, etc. Almost all of these special steels require some form of heat treatment following their finish and prior to being put into service.

STEEL (Titanium). A steel generally made by either the Bessemer or open hearth process, to which titanium alloy has been added in such quantity as to give the molten metal the benefit of about 0.10 per cent of metallic titanium. Being a powerful deoxidizer, titanium acts on the metal similarly to manganese, while at the same time it restricts segregation and by making the metal dense increases its resistance to wear, especially in rail steel. A very small trace of titanium remains in the finished steel. Titanium steel rails have shown desirable wearing qualities.

STEEL (Tungsten). An alloy steel that usually contains from 15 to 20 per cent of tungsten and from 0.4 to 2 per cent of carbon. Tungsten steel possesses the property of hardening in the air after having been heated to a high temperature and retains its hardness at a dull red heat. For this reason it is particularly adapted for high-speed, metal-cutting tools. In modern high speed steel the Tungsten content is from 17 to 18 per cent. These steels should receive a double quenching or slow cooling from 1800 deg. F. to 900 deg. F. and then rapid cooling to air temperature. A tungsten content of 1.5 to 3.5 per cent in steel increases the resistance of the metal to abrasion and to tension and torsion stresses.

STEEL (Vanadium). A high-speed tool containing various vanadium contents usually from 0.5 to 2.0 per cent. Vanadium deoxidizes and increases the toughness of the metal and adds to the fine qualities of the metal under tension, torsion or alternate stresses.

T

TAMP. To pack in and down by ramming or prying together the particles of material; as ballast under the ties of railway track, concrete freshly placed in the forms, back-fill at the sides of culvert pipe, or explosives in a hole drilled for blasting. See Back-fill. Also Concrete. Also Ballast Tamping, (Track Section). Also Culvert, (Bridge Section).

TAR, COAL (Coal-Gas). Tar obtained as a by-product from the destructive distillation of coal in the manufacture of coal gas. It is one of the sources of creosote.

TAR, COAL (Coke-Oven). Tar obtained as a by-product from the destructive distillation of coal in the manufacture of coke. About ten gallons of tar are obtained in coking one ton of coal. It is one of the sources of creosote.

TEMPLET. A gage, a pattern or a mold, sometimes a thin plate or a board used as a guide for the form of work to be executed. Ordinarily a templet for each individual member of a structure is made in the shop. Where templets are needed for large members it is necessary to make drawings which are usually made on the shop floor and templets are then made to the dimensions of the drawing.

TORCH. A light formed of some illuminating device, such as a metal oil container with a wick in a short spout.

Enginemen's torches have handles for carrying them about while examining machinery, etc.

TRUE. Of uniform cross section. (A. R. E. A.) This term is employed to express the uniformity of surfaces, especially with reference to the regularity resulting from the sawing of structural timber.

U

U-BOLT. A bolt bent in the middle until its two halves form equal parallel bars, the bolt assuming the form of the letter U. These bolts are used to hold a member within the curve while its ends engage a second number.

V

VARNISH. A clear limpid fluid which results from dissolving and cooking resinous matter in oils or spirits, which hardens without losing its transparency and which is used by painters as a top coat to give a hard, shining, moisture-resistant surface.

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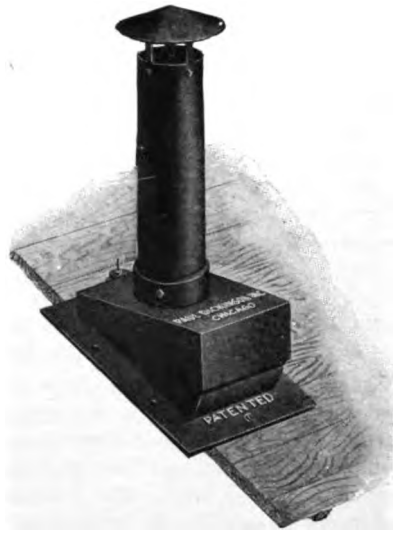
The resinous ingredients may include rosin, amber, copal, mastic shellac, sandarac and anime, which may be colored with gomboge, saffron, asphalt, etc. The oil solvents are fixed or volatile oils or mixtures of them, such as linseed oil and spirits of turpentine, while the spirits are concentrated alcohol or methylated spirits.

Varnish is used as a finish on hardwood floors and ceilings, its color being varied to suit the color of the wood. Clear, transparent, rapid drying varnishes are desirable for floor finish and for enamels of which it forms the liquid portion. Varnish is tested by the exposure method, its qualities of drying to a clear, hard glossy surface in a certain number of hours, its retention of the gloss without whitening or dulling after subjection to alternate streams of cold and boiling water indicating quality. It is also subjected to quick bending tests on tin panels to determine its elasticity and is exposed to the sun to further determine its durability. When such tests are not practicable, the action of the sample as compared with samples of varnishes of known quality can be quickly determined.

VENTILATOR. A device for carrying away injurious gases from an enclosed space, replacing vitiated or impure air by fresh air, as a hood or cap at the top of a vent shaft, contrived to prevent down drafts and create up drafts, or a shielded opening in a roof connected with the exhaust system of ventilation. Ventilators are also placed in the ceilings of rooms or at the tops of any enclosures to be ventilated, the ulimate object being to provide an opening for the escape of the gases. Sometimes the current of air from the structure is accelerated by placing a fan or other moving part in the ventilator or the resistance of outside air currents is overcome by providing a side aperture protected by a weather vane in the direction of the wind. Some ventilators are bottomless roofed boxes with slats in the sides set on the roof, as is frequent in engine houses. Again a ventilator may have a revolving horizontal concave fan at the top of the shaft under the cap, or it may be provided with a gravity damper with a fusible link to shut off the draft automatically in case of fire. The aperture in the ventilator may be a narrow channel between inturned flaring sides under a raised and vertically curved cap strip, to cause a suction with the wind in any direction. Another type is a globular fan revolving on a vertical axis at the top of a cylinder, while still other types have apertures for overdrafts of outer air that produce upward suction. Ventilators are made of cast iron, pure iron, galvanized iron, tin, brass, zinc and other metals as well as wood, etc.

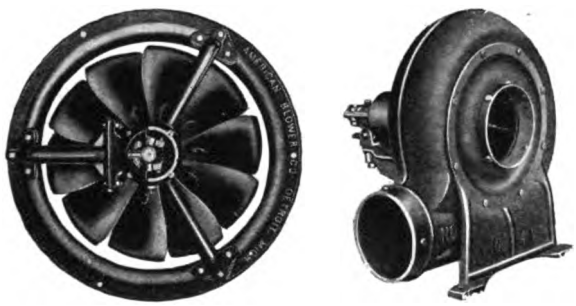
Ventilator shafts and mechanical fans and blower systems are also used for buildings and tunnels. Chimney flues, registers, wall flues, cold air tunnels and intakes are among the devices used to induce, accelerate and perfect ventilation. See Ventilation. Also Sanitation.

VENTILATION. The process of supplying fresh air to the interiors of buildings, tunnels and the like to maintain a constant acceptable standard of purity.



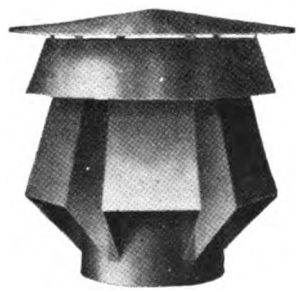
Adjustable Cast Iron Chimney for Sloping Roof
Paul Dickinson, Inc.
(See Page 682)

Ventilator
The Merchant & Evans Co.



Venturi Disc Ventilating Fan and Universal Blower
The American Blower Co.
(See Page 630)

Camp Car Jack
Paul Dickinson, Inc.
(See Page 682)



Dickinson Aelus Ventilator
Paul Dickinson, Inc.
(See Page 682)

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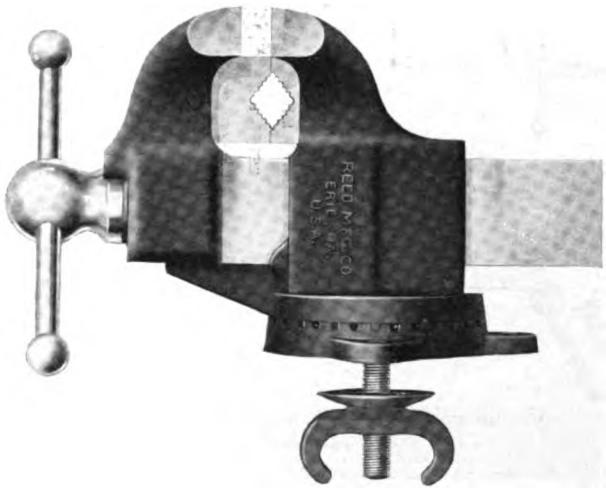
The movements of confined air produce a sense of coolness but are not to be confused with ventilation. Ventilation may be at the atmospheric pressure, depending on a natural constant exchange of vitiated air for fresh air at an imperceptible rate as is desirable in dwellings, or passenger station, or it may be forced by means of drafts of air created by machine driven fan blowers, etc., as is frequently found desirable in engine houses, blacksmith shops, etc. See Ventilator.

VISE. A wood or metal gripping and holding device. This bench tool consists essentially of two jaws operated by a screw or other mechanism for holding objects rigidly and without recoil while work is being performed, as a saw while filing or a pipe for threading. An all-metal type in general use has a body which is secured at the base to the work bench by means of bolts or clamps, its cubical central portion being horizontally bored from front to back with a threaded hole to receive a threaded cylindrical bolt or screw, while the top portion is bent forward 90 deg. to form a fixed jaw with a vertical rectangular gripping surface. The movable jaw is a one-piece casting formed like and facing its fixed mate, but terminating at the bottom in a hollow threaded cylindrical collar, through which the screw passes. The collar bears against the shoulder of the screw head which is bored to receive the movable steel screw handle. Wooden vises are also used in wood working shops, some bench vises being made of a screw and one movable board jaw which clamps against the side of the bench. Pipe vises having special serrated vertical jaws and screw with self-locking attachment or horizontal pipe jaws are provided in combination with the mechanics type of vise.



Combination Vise

Filer's Vise

VISE, STEAM FITTERS. See Vise, Pipe, (Water Service Section).

W

WANE. The lack of timber in the edge of a board or other manufactured piece designed for rectangular section, which is due to the natural curvature of the log. See Tie, (Track Section).

WARP. To turn or twist out of a straight line, as a board or timber warping is generally caused by unequal shrinkage, rapid seasoning of green lumber after manufacture, forcible and long continued bending, etc.

WASHER. A plate of metal or other material, usually annular, which is placed on a bolt or rod to give better bearing to the nut or bolt head or to lock the nut.

Washers are in most general use on metal bolts which penetrate wooden parts, but are also common in all metal construction. Comparatively large washers of cast iron or wrought iron are used in wooden bridges and trestles on stringer chord bolts, etc. Washers are also used in the erection of fabricated steel structures, such as bridges and buildings, where they are employed frequently with temporary or setting-up bolts, and removed as the permanent rivets are driven. They are also generally used to lock the nuts on track and machine bolts. See Bolt. Also Nut Lock. Also Lock Washer, (Track Section).

WATERPROOFING. Any material introduced in or on the surface of a wall, floor, roof or other surface to exclude rain, snow or any other form of moisture, particularly water under pressure as in a scale pit which is below the level of the surface of a nearby body of water.

Building foundation walls are waterproofed on the outside from the bottom to the ground line and the coating allowed to dry or set or permeate before the fill is put in place. The usual coating is hot liquid pitch or a waterproof paint or a filler.

Waterproofing
The Minwax Co., Inc.
(See Page 748)

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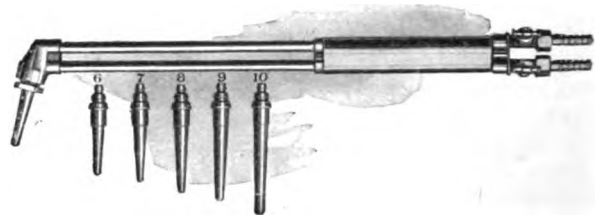
Applying Sarco Mineral Rubber Waterproofing
The Standard Asphalt & Refining Co.

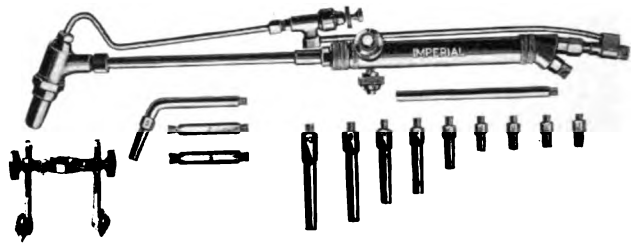
The insulation should always be placed on the surface from which water tends to enter the structure, as on the outside of walls. As this is not possible in floors laid on the ground the insulation is sometimes laid on the first thin layer of floor such as concrete, in the form of sheets of ready roofing or some similar material. This is coated with pitch and other layers added as in built-up roofing, the ends of the sheets being turned up at the walls and the entire enclosure flashed to the desired height with the built-up insulation. A similar process is adopted with scale pit floors where great care is necessary to keep the pit dry if below ground water. (See Page 734 and 748).

WELD. To press or beat pieces of the same metal, as two steel bars, into intimate and permanent union, usually while softened by intense heat; also to unite by fusing heat produced by gases emitted from pressure tanks through separate lines of hose to a gas blow pipe, or by means of an electric arc.

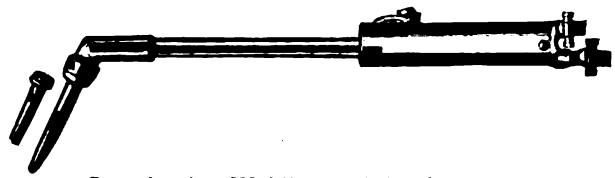
WELDING (Blow Pipe). The uniting of pieces or parts of the same metal by fusion effected by means of gases emitted from pressure tanks, hose-connected to a blow pipe commonly known as a torch, so constructed as to concentrate and direct the flame produced by the united gases, which melt the metal so that the parts may be joined into one solid piece of the same character and structure throughout. This process of welding high melting point metals such as steel is made possible through the availability of certain highly compressed gases in portable steel cylinders. Oxygen gas is compressed safely in these containers to 1800 lb. per square inch, while acetylene is purified and absorbed in tubes filled with a porous substance such as pumice, charcoal or asbestos at a maximum charging pressure of 250 lb. per square inch at 70 deg. Fahrenheit, the porous substance being saturated with a liquid solvent having the property of dissolving many times its volume of acetylene under pressure.



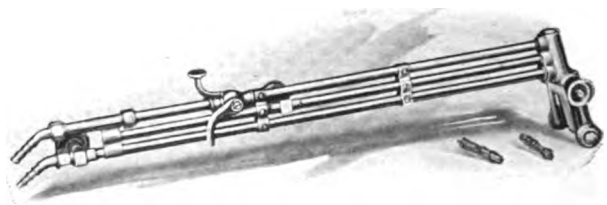
Welding Torch
The Davis-Bournonville Co.



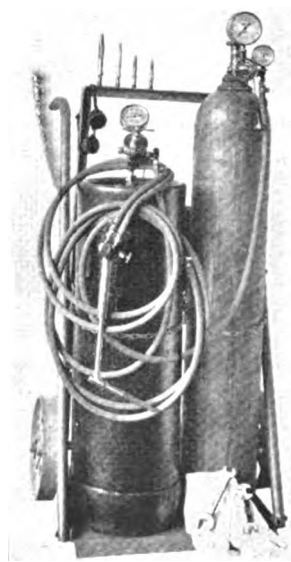
Imperial Combination Welding and Cutting Torch
The Imperial Brass Manufacturing Co.



Combination Welding and Cutting Torch
The Alexander Milburn Co.



Cutting Torch
The Macleod Co.



Oxweld Welding Outfit
The Oxweld Railroad Service Co.
(See Page 765)

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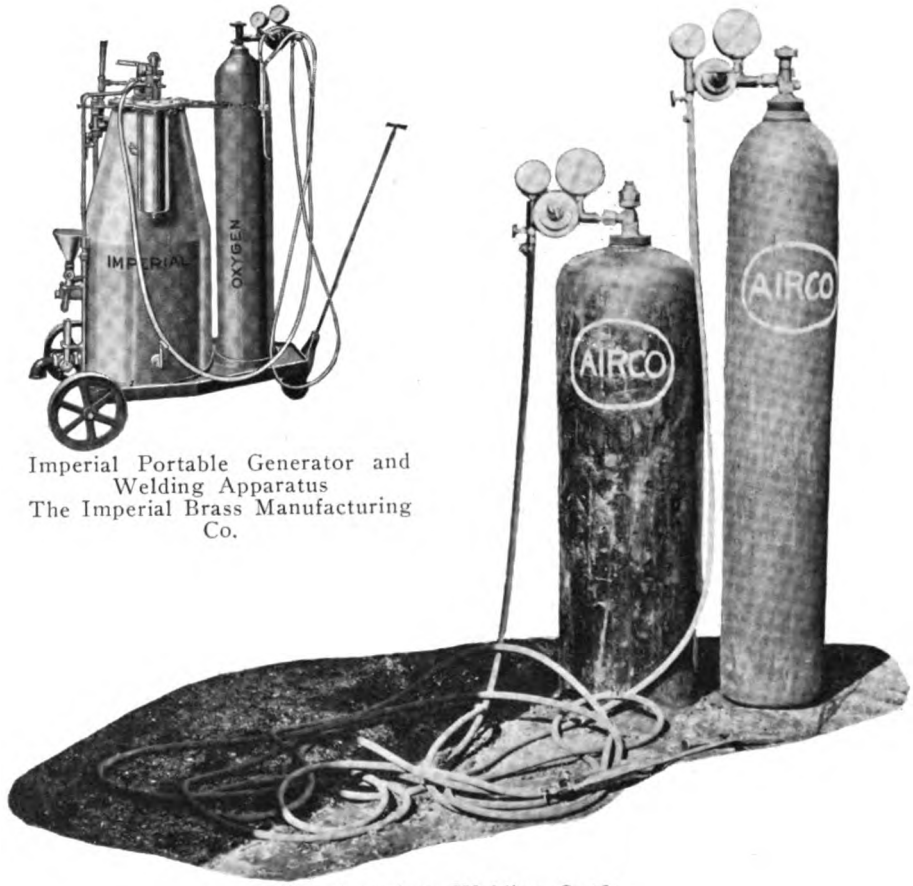
Carbo Portable Cutting Outfit
The Carbo-Hydrogen Company of America

Portable Cutting and Welding Outfit with Acetylene Generator
The Macleod Co.

Portable Oxy-Acetylene Welding and Cutting Equipment
The K. G. Welding and Cutting Co., Inc.

Imperial Portable Generator and Welding Apparatus
The Imperial Brass Manufacturing Co.



Oxy-Acetylene Welding Outfit
The Air Reduction Sales Co.

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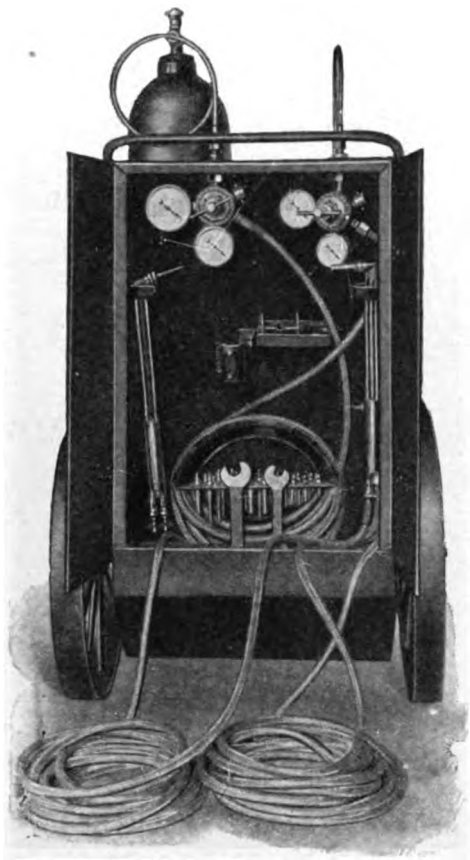
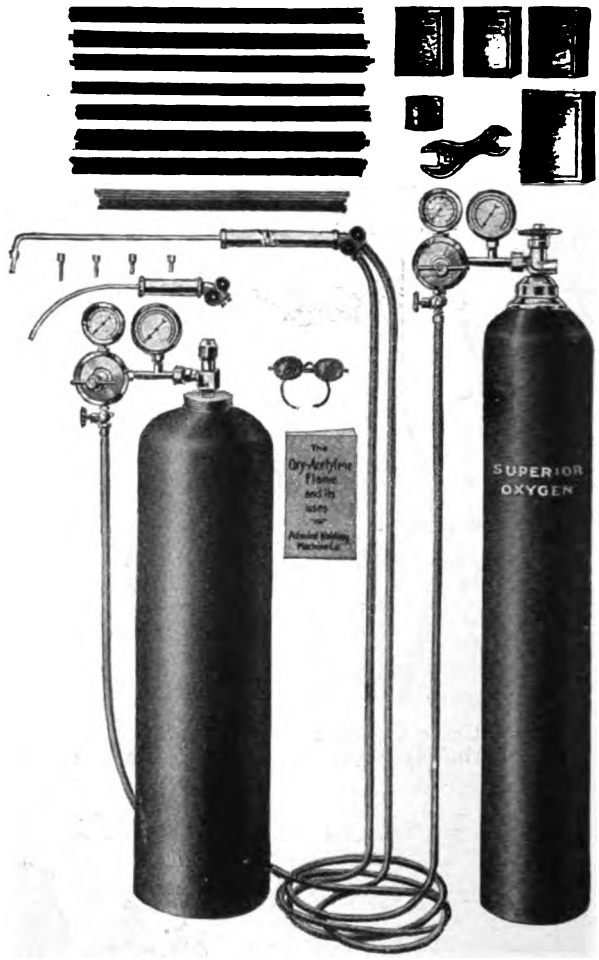
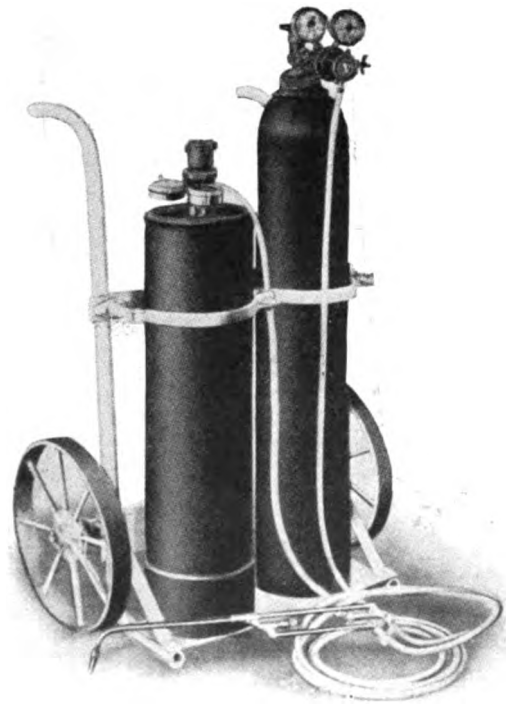


Portable Welding and Cutting Apparatus on Cabinet Truck
The Davis-Bournonville Co.



Admiral Welding Equipment
The Admiral Welding Machine Co.



Portable Welding and Cutting Outfit
The Alexander Milburn Co.

Welding Outfit
The Federal Brass Works

Hydrogen and oxygen are similarly used, more especially to weld cast iron and sometimes copper, brass and aluminum, the connections from the tanks being made by means of special hose. A gas containing about 85 per cent hydrogen and 15 per cent light hydrocarbon, combustible but non-explosive, is used principally for light welding in iron and steel and for welding the softer metals. It burns almost

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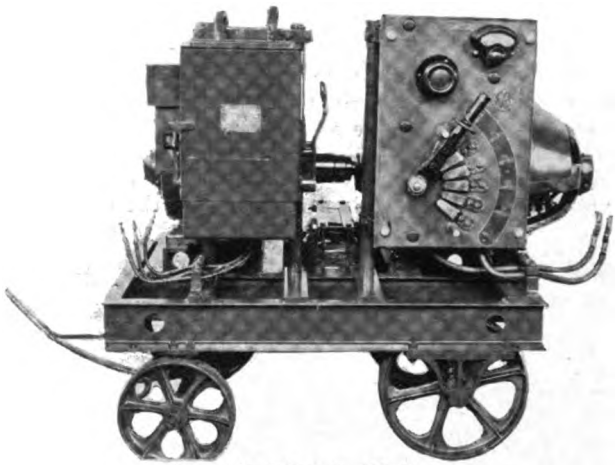
entirely to water, does not harden the metals welded, leaves no residue in the tank and very little slag results from the welding which is done in a manner similar to the oxy-acetylene process. An advantage of cutting metals with the blow pipe is the accuracy and smoothness with which the cut may be made. The electric arc is likewise used as a means of cutting metal, the fusing heat being applied directly in the line of the proposed cut.

Blow pipe welding and cutting, sometimes called autogenous, is made readily available for field work in the maintenance of way departments of railways through the portability of the apparatus including reserve supplies of the necessary gases in pressure containers and sometimes generators. These outfits are valuable for building up worn crossing and turnout frogs in place, for cutting apart the steel parts of wrecked cars and for bridge alterations. It is likewise generally employed in railway shops to cut, weld and patch steel work.

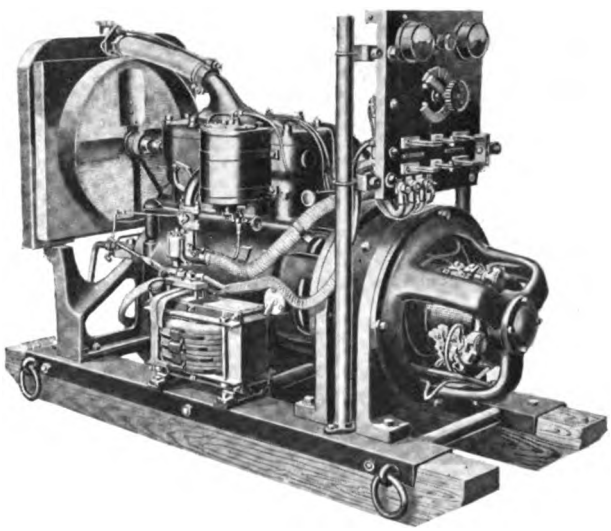
WELDING (Electric). Joining pieces of the same metal by fusion produced by an electric arc and filler metal supplied from a melted rod.

In electric welding the current is passed through the parts to be joined, the resistance offered to the

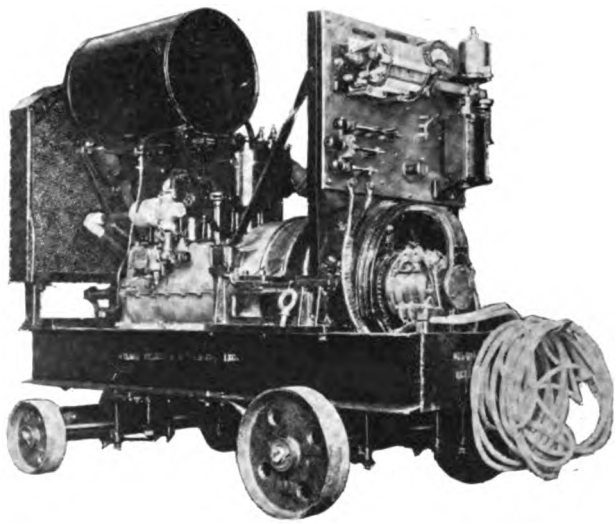


Portable Electric Welder
The General Electric Co.
(See Page 694)

Electrolytic Oxyhydrogen Generator
The International Oxygen Co.



U. S. L. Gasoline Engine Arc Welding Equipment
The U. S. Light & Heat Corporation
(See Page 821)



Portable Gasoline Engine-driven Generator for Plastic Arc Welding Outfit
The Wilson Welder & Metals Co.

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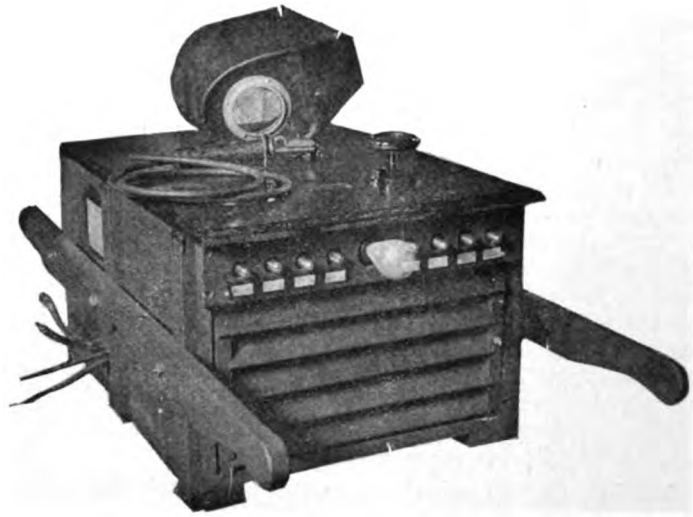
Thermit Rail Welder
The Metal & Thermit Corporation



Standard Alternating Current Cutter and Welder
The Electric Arc Cutting & Welding Co.

passage of the current at the point of contact producing the welding heat, while sufficient pressure is applied to affect the union. Another form of welding known as carbon arc welding is one in which the work to which metal is to be added forms the positive pole of a direct current circuit and the arc is drawn between the work and a carbon rod to which a handle is attached for manipulating. At the point of arc contact on the work, the metal becomes molten, while the metal which is necessary to add to the weld is supplied by melting the filler rod in the arc, the minute globules of molten metal commingling and fusing with the parts to be welded together.

Still another form of electric welding consists of drawing an arc between a metallic electrode and the parts to be welded. The electrode is usually a wire or small rod, which may or may not be similar in composition to the metal to be welded. The arc is established by striking the wire electrode to the work with a dragging touch and then withdrawing it to a distance of approximately ⅛ in. The electric welder consists usually of a power-driven, direct, portable or stationary dynamo, an electrode holder and controlling apparatus; or a portable transformer enclosed in a wooden box and the necessary controlling apparatus and electric holder.

The use of electric welding apparatus for maintenance of way departments is limited to the repair of worn or broken parts of turnout and crossing frogs and other railway material at shops where electric current is available.

WELDING, FUSION. Any process of welding in which the union of the pieces of metal is effected by means of melting and fusing together without pressure. Fusion welding includes the electric arc process as well as the blow pipe process. See Welding, Electric. Also Welding, blow pipe.

WHEELBARROW. A load-carrying contrivance with one wheel in front, a tray in the middle, two legs at the rear on which it rests and two handles behind them by which a workman lifts the legs from the ground and carries a part of the weight while he pushes the vehicle forward on the wheel.

Tubular Steel Wheelbarrow

Concrete Wheelbarrow

The type of wheelbarrow in common use for concrete construction is all-steel and has a 1⅛ in. tire, a 16 in. diam. wheel, the axle of which turns between bearings at the front ends of a pair of shafts which support a flaring tray of about 3 cu. ft. capacity between the wheel and the double-braced legs. The shafts diverge and rise from the wheel backward to about 2 ft. 6 in. apart and 24

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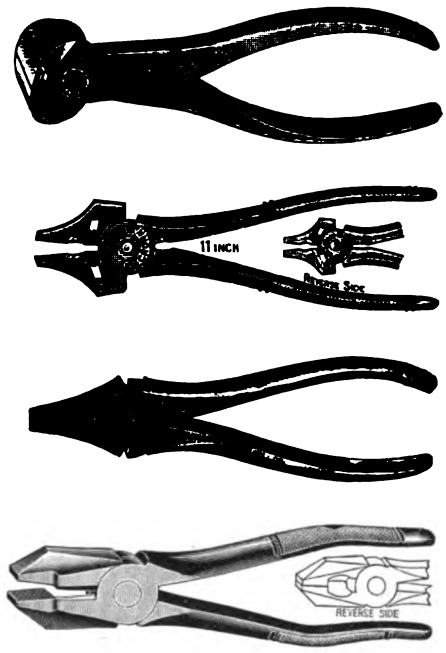
Wooden Wheelbarrow

in. high at the handles. Other similar styles of railway wheelbarrows in use for handling dry materials are all hardwood, while some have steel trays on wooden frames.

WHITEWASH. A composition of quick-lime and water, or of a whiting size and water, used for whitening woodwork, brickwork, the plaster surface of walls, etc.; especially for masonry walls in shops, in the basements and cellars of houses, for the aprons and wing fences at stock guards.

WHITING. A preparation of dried and ground chalk, used in fine whitewashing and in distemper painting, also in making putty. See Whitewash.

WIRE CUTTER. A pair of steel pliers for cutting, holding and bending wire, commonly consisting of two mated steel pincer parts crossed and riveted together at the shoulder and terminating in



Four Common Styles of Wire Cutters

convexly curved handles, which when pinched together in the hand, close the pliers forceps-fashion. The tapering jaws usually have rectangular adjacent ridged wire clasping faces in front of a flat projecting knife-like cutter or side cutting nipper; or the jaws may be claw-shaped and so tapered and beveled that they meet in bit and cutting edges; or the pliers may be blunt nosed and oppositely notched at the axis so as to admit a wire when the handles are opened and shear it when they are closed together.

WIRE GAGE. A device used to measure the sizes of wires, usually under ½ in. diameter, in terms of certain arbitrary scales.

The gage of a wire is designated by a number, as for example, No. 10 B. & S. gage. This number refers to the cross sectional diameter perpendicular to the length of the wire. A number 10 gage wire in one gage table however will not have the same diameter as a wire of the same number, in another table. Generally wires over ½ in. in diameter are spoken of in terms of their sectional areas expressed in circular mils, a circular mil being the area of a circle one mil in diameter.

SMOOTH STEEL WIRES

Cuts showing exact sizes of No. 1 to No. 20 gage steel wire by American Steel & Wire Company gage.	Gage	Lb. to Mile	Feet to 1 Lb.
	1	1121	4.71
	2	968	5.45
	3	833	6.34
	4	707	7.47
	5	599	8.81
	6	514	10.28
	7	439	12.05
	8	367	14.37
	9	306	17.24
	10	255	20.70
	11	202	26.18
	12	154	34.25
	13	118	44.64
	14	89	59.17
	15	72	73.00
	16	55	95.24
	17	41	129.87
	18	31	172.11
	19	24	222.22
	20	17	312.50

Steel Wire Gage

A number of wire gages are in use, the principal ones being the American or Brown and Sharpe (expressed as A. W. G. or B & S.); Birmingham (or Stubs') (expressed as B. W. G.); British Standard (abbreviated S. W. G. and usually called the Standard wire gage); Edison wire gage and the

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U. S. Steel wire gage (frequently abbreviated S. W. G., but to avoid confusion should be Stl. W. G. or A. (steel) W. G.). Other gages are the Stubs' steel wire gage and the Old English or London gages.

The American or Brown & Sharpe gage is generally used in the United States for copper, aluminum and resistance wires. All diameters are in geometrical progression, the largest wire, No. 0000 having a diameter of 0.46 in. and the smallest, No. 36, being 0.005 in.

COMPARISON OF WIRE GAGES

Diameters in Mils

(Bureau of Standards, Circular No. 31)

Gage No.	American wire gage (B.&S.)	Steel wire gage	Birm'gham wire gage (Stubs')	Old English wire gage (London)	Stubs steel wire gage	(British) Stand'd wire gage	Gage No.
7-0	....	490.0	...	....	...	500	7-0
6-0	....	461.5	...	....	...	464	6-0
5-0	....	430.5	...	....	...	432	5-0
4-0	460	393.8	454	454	...	400	4-0
3-0	410	362.5	425	425	...	372	3-0
2-0	365	331.0	380	380	...	348	2-0
0	325	306.5	340	340	...	324	0
1	289	283.0	300	300	227	300	1
2	258	262.5	284	284	219	276	2
3	229	243.7	259	259	212	252	3
4	204	225.3	238	238	207	232	4
5	182	207.0	220	220	204	212	5
6	162	192.0	203	203	201	192	6
7	144	177.0	180	180	199	176	7
8	128	162.0	165	165	197	160	8
9	114	148.3	148	148	194	144	9
10	102	135.0	134	134	191	128	10
11	91	120.5	120	120	188	116	11
12	81	105.5	109	109	185	104	12
13	72	91.5	95	95	182	92	13
14	64	80.0	83	83	180	80	14
15	57	72.0	72	72	178	72	15
16	51	62.5	65	65	175	64	16
17	45	54.0	58	58	172	56	17
18	40	47.5	49	49	168	48	18
19	36	41.0	42	40	164	40	19
20	32	34.8	35	35	161	36	20
21	28.5	31.7	32	31.5	157	32	21
22	25.3	28.6	28	29.5	155	28	22
23	22.6	25.8	25	27.0	153	24	23
24	20.1	23.0	22	25.0	151	22	24
25	17.9	20.4	20	23.0	148	20	25
26	15.9	18.1	18	20.5	146	18	26
27	14.2	17.3	16	18.75	143	16.4	27
28	12.6	16.2	14	16.50	139	14.8	28
29	11.3	15.0	13	15.50	134	13.6	29
30	10.0	14.0	12	13.75	127	12.4	30
31	8.9	13.2	10	12.25	120	11.6	31
32	8.0	12.8	9	11.25	115	10.8	32
33	7.1	11.8	8	10.25	112	10.0	33
34	6.3	10.4	7	9.50	110	9.2	34
35	5.6	9.5	5	9.00	108	8.4	35
36	5.0	9.0	4	7.50	106	7.6	36
37	4.5	8.5	...	6.50	103	6.8	37
38	4.0	8.0	...	5.75	101	6.0	38
39	3.5	7.5	...	5.00	99	5.2	39
40	3.1	7.0	...	4.50	97	4.8	40
41	....	6.6	...	....	95	4.4	41
42	....	6.2	...	....	92	4.0	42
43	....	6.0	...	....	88	3.6	43
44	....	5.8	...	....	85	3.2	44
45	....	5.5	...	....	81	2.8	45
46	....	5.2	...	....	79	2.4	46
47	....	5.0	...	....	77	2.0	47
48	....	4.8	...	....	75	1.6	48
49	....	4.6	...	....	72	1.2	49
50	....	4.4	...	....	69	1.0	50

The Birmingham (or Stubs' gage) is used to a limited extent in the United States for some purposes, as in connection with the size of brass wire, and it is used also to a small extent in Great Britain. The gage is used for wires under ½ in. in diameter, the size being designated by numbers, each number representing a diameter in decimal parts of an inch.

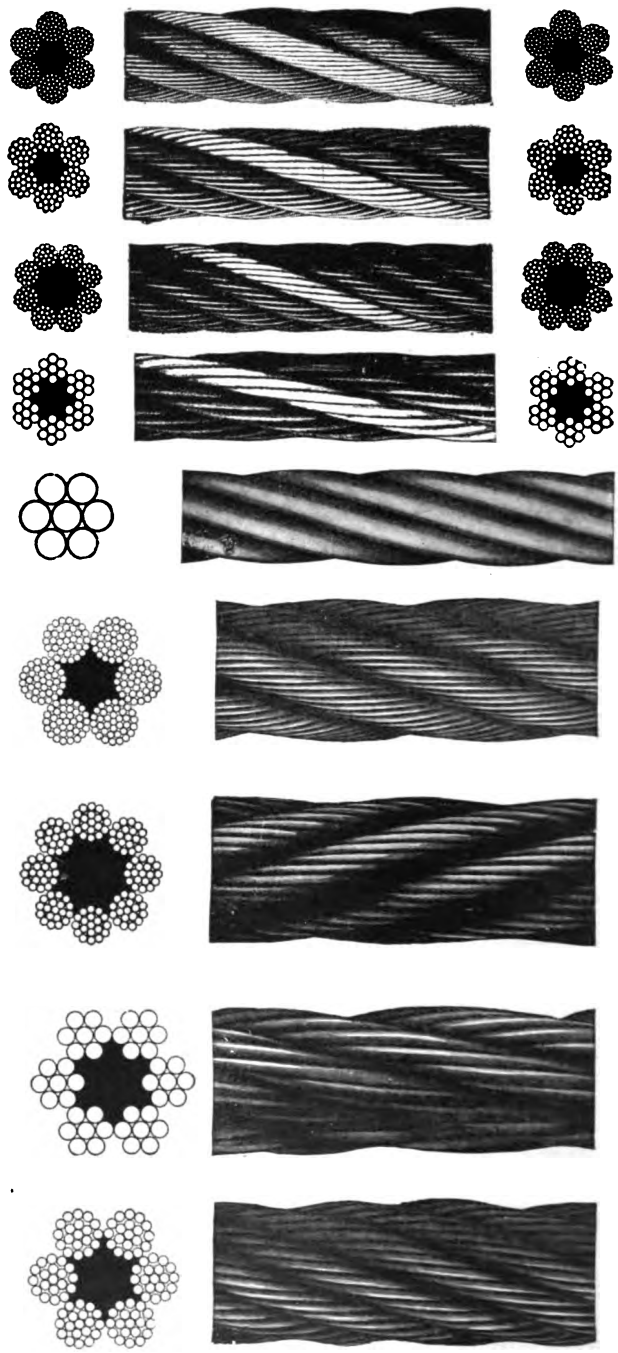
The British Standard Wire gage, also known as the New British Standard (N. B. S.), is the legal standard in Great Britain for all wires.

The size of a wire in the Edison gage is equal to its cross sectional area in circular miles, divided by 1000. This gage is seldom used.

The U. S. Steel wire gage is generally employed in the United States for steel and iron wire. This gage is also known as the American Steel & Wire Co. gage, Roebling and Washburn and Moen.

WIRE ROPE. A cord or line over 1 in. and less than 10 in. in circumference made by twisting together a number of drawn wires into several separate strands and then twisting these strands together around a central hemp core, which helps to preserve the uniform shape of the rope and acts as a cushion to the strands.

When the strands are twisted about a central core of wire and the circumference is 10 in. or more the



Nine Types of Wire Ropes with Cross Sections Showing Arrangements of Strands

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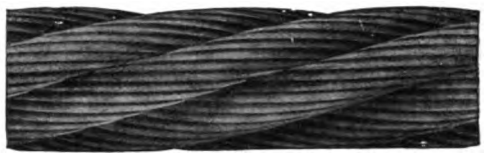
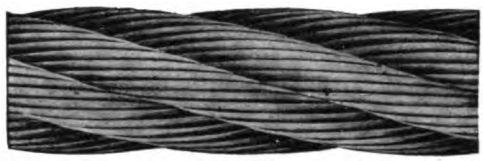
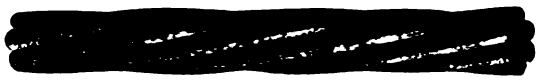


Left Hand Regular Lay Wire Rope



Right Hand Regular Lay Wire Rope

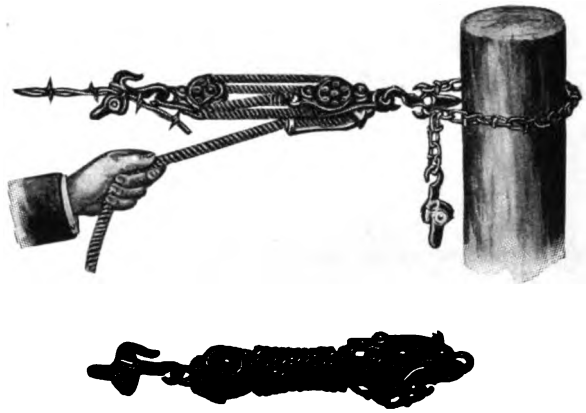
Lang's Lay Wire Rope



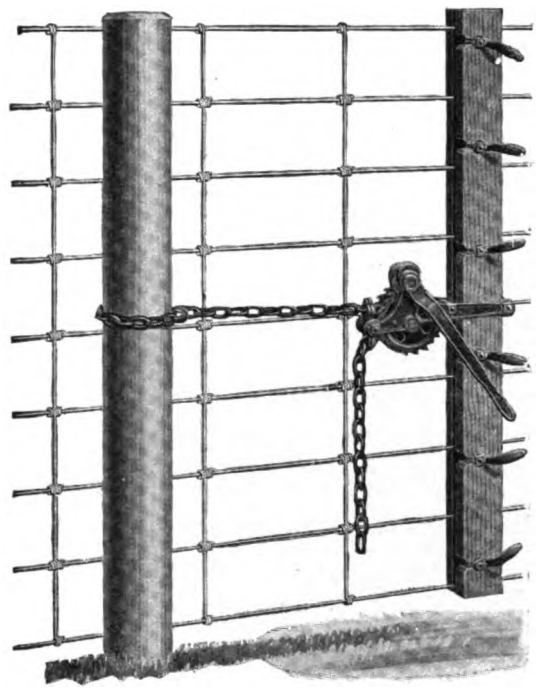
Galvanized Wire Strand Rope

line is called a cable, the wire core adding rigidity and tensile strength. The standard construction of wire rope is to twist the wires toward the left to make a strand and the strands toward the right to make the rope. This is known as right lay rope, and when oppositely twisted it is known as left lay rope. In Lang's lay rope, however, the wires in the strands and the strands in the rope are all twisted in one direction. The number of wires and the number of strands used, their shape and the manner of arrangement depends on the service for which the particular rope is intended. For ordinary work, a heavy duty wire rope is of 6 strands, each strand consisting of 7, 19 or 37 drawn wires; or the rope is frequently made of 8 strands of 19 wires each. Light service wire lines such as are used for guy lines, small derricks, etc., commonly consist of 7 galvanized wires twisted together into single strand rope. While wire rope is obtainable in either galvanized or bright wire, it is considered desirable that those continually exposed to dampness such as guy lines, conveyor ropes, etc., should be galvanized and lubricated, while those used over sheaves and pulleys also should be lubricated to minimize friction among the wires, the strands and the core. See Rope. (See Page 638 and 747).

WIRE STRETCHER. A machine for stretching wire as in fencing, usually consisting of a metal frame holding a gear, pawl, lever and chain designed to be attached to a pair of wooden cross-arms about 5 ft: long bolted uprightly together, one on either side of the wire fencing, the bolts bearing against the vertical stay wire joints and the machine being held in position by a chain fastened to a



R. W. Tackle and Fence Wire Stretcher
The Richards-Wilcox Manufacturing Co.



R. W. Dragon Wire Fence Stretcher and Hoist
The Richards-Wilcox Manufacturing Co.

fence post and passing over a gear in the frame. Another type of stretcher especially adaptable to tightening single fence wires consists of double wood or iron blocks and tackle.

WOOD GRAPPLE. A machine gripping hook with line hinged unlocking claws designed to be used in connection with a crane or derrick to handle ties and lumber, in a manner similar to that in which loose materials are handled with grab buckets. The wood grapple is a grab bucket specialty having hooks attached to the hinge shafts in place of trays. See Grab Bucket.

WRENCH (Monkey). A sliding jaw wrench for screwing and unscrewing nuts of various sizes. This adjustable wrench consists of a pair of parallel steel jaws, one of which is a right angle hook terminating the flat wrench handle or shank along which its mate can be moved to and from it by means of a

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Two Types of Monkey Wrenches

sleeve nut working on a thread cut on the stem or on a screw parallel with and housed along the edge of the stem, which sometimes ends in a wooden hand grip.

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The Catalog Section

The Catalog Section of the Cyclopedia is designed to supplement the Text Section in the way that is required to connect the methods and principles of maintenance of way work with the devices and equipment by which these methods and principles have been worked out not only on a practical but on a commercial basis.

The Catalog Section is arranged with a view to supplementing the general information of the Text Section with itemized description and illustrations of specific devices which will enable the reader to complete the mental picture of each device, and in addition also to visualize its practical adaptation to the specific work which it is intended to perform. This section therefore presents in concrete form the various means by which the general principles covered by the Text Section have been worked out commercially.

In the preparation of the catalog section the same editorial standards that have governed the preparation of the Text Section have been kept in view. The greater part of the section has been prepared, in co-operation with manufacturers, by our own staff, composed of men who have had not only long connection with railway work, but also extended experience in the preparation of printed matter of this kind; while that portion prepared by manufacturers themselves has, also with their co-operation, been edited by our staff to conform substantially to such standards. The Catalog Section therefore supplies in similar form information which does not come within the plan and scope of the body of the book, but which is germane to the subjects treated and will be found of great value to those who use the Cyclopedia.

The Catalog Section has been edited by:

E. T. Howson, Western Editor, Railway Age, and Editor Railway Maintenance Engineer.

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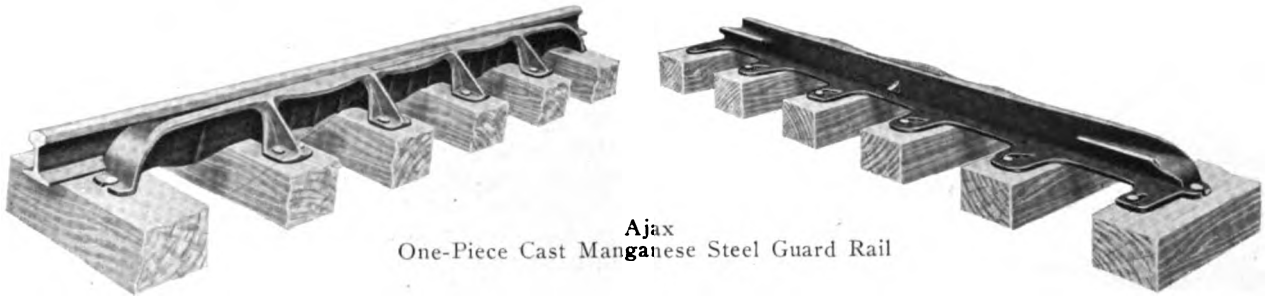
General

The Ajax Forge Company, having plants in Chicago, Ill., Superior, Wis., and Oakland, Cal., has been engaged for 35 years in the manufacture of standard and special track materials, including frogs, switches, crossings, and guard rails of rolled rail and cast manganese construction, also switch stands, guard rail clamps, rail braces, and other track accessories. Of these several products the company specializes in the manufacture of rail braces and manganese steel guard rails, and is the manufacturer of the Ajax Manganese Steel One-Piece Guard Rail.

main track rail, the guard rails often can be used advantageously in providing a means of preventing the pony trucks of locomotives from climbing the traffic rail and of holding blind drivers to a curve, without interferring with snow flangers. The value of guard rails in this respect depends upon the rolling stock, the curve, the condition of the road bed, etc. It has been determined that an engine with an 11 ft. rigid wheel base, with the forward wheels of the pony trucks 10 ft. ahead of the driver and carrying but 15 per cent of the load, will climb when the side thrust exceeds that load, and at times, on heavy curves and soft road bed, the settlement of the drivers will raise the pony trucks entirely off the rail.



Ajax
One-Piece Cast Manganese Steel Guard Rail

The Ajax One-Piece Guard Rail

This latter product of the Ajax Forge Company is a recent development in guard rail construction which has attracted very favorable attention in the maintenance field. The device is built of cast manganese steel, and, as the name implies, is a one-piece construction, the rails, bolts, clamps, plates, braces, and foot guards which make up the ordinary rail type of guard rails, being either omitted or combined in the one casting.

There is much about a guard rail of this kind to merit attention, particularly on important tracks. Manganese steel itself is so resistant to shock and wear that it is now regularly used in the better class of frog and crossing construction, and it has been amply demonstrated that cast manganese steel is an excellent form of it. It is obvious that, other things being equal, the tendency of a one piece guard rail is to reduce the trouble of handling and installing and, to an even greater degree, to decrease the amount of attention and repair required by rail guard installations, which, sometimes comprise as many as 30 to 60 separate pieces. The nature of the construction eliminates the need of drilling holes through the web of the traffic rail or of spiking between rails, and by the nature of the grip exerted upon both sides of the traffic rail, it not only fulfills the purpose of the guard rail clamp in holding the guard and traffic rail together, but maintains a constant working distance between the guard rail and the facing frog point opposite. This is a special advantage of the Ajax guard rails where No. 6 or No. 7 turnouts are frequently subjected to the side thrust resulting from the passage of locomotives designed only for the larger turnouts.

By providing a continuous plate beneath the traffic rail, these guard rails conform to the best practice concerning the use of surface plates, and also eliminate rattling with its resulting injury to the ties and roadbed. Also when made ¾-in. higher than the

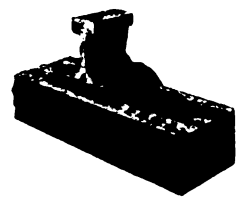
Ajax guard rails are made in sizes ranging from 4¼-in. to 6½-in. in height for all sections of rail and are sold by the piece. Since their introduction the devices have come into extensive use on American railroads and are giving service fully up to expectations.

Rail Braces

The Ajax Forge Company also manufactures steel rail braces of three types. Of these the Detector Bar Brace is made to provide room for the movement of the detector bar on the side of the rail and brace. The second brace is the Ajax Standard Rail Brace, made to fit over the railroad's standard tie plate, or without offset where no tie plates are used. The third brace, the Ajax

Ajax Detector Bar Rail Brace

Ajax Standard Rail Brace



Ajax Special Rail Brace

Special Rail Brace, is made with special offset to fit over spikes and tie plate. These braces are of forged steel plate and are designed with a hump of a suitable shape to resist side thrust. They are very durable and can be successfully removed and reused many times.

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General

The American Blower Company, Detroit, Mich., specializes in the "ABC" and "Sirocco" blower equipment, for the heating and ventilation of railroad shops; the heating of pits and exhausting of smoke and gases at round houses; the drying of paint at paint shops; the exhausting of gases and machine waste at forge shops; the ventilation of terminals; the washing of the air and the heating and ventilation of offices; and for mechanical and forced draft at boiler rooms.

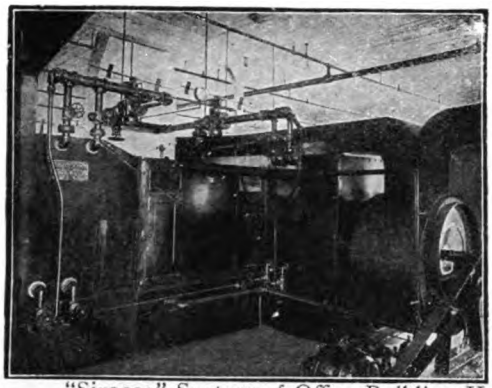


Fig. 1

"Sirocco" System of Office-Building Heating, Ventilating, Purifying and Cooling

10 is the Ventura Disc Ventilating Fan, for handling large volumes of air at low power costs.

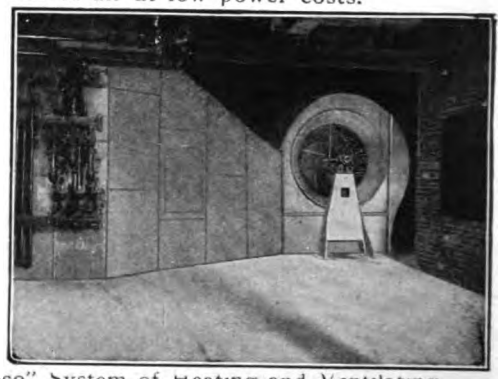


Fig. 6

"Sirocco" System of Heating and Ventilating for Public Buildings

The Detroit Tilting Steam Trap, Fig. 7, is built in Return Separating, Vacuum and Condensing Types. It is used for automatically returning condensation from steam lines direct to the boiler without pumping.

Fig. 7

Fig. 2

Fig. 3

Fig. 8

Fig. 9

Fig. 10

Fig. 2 illustrates the type E. Exhaust Fan, for exhausting and conveying systems, and Fig. 3, the Sirocco Electric Utility Blower, built in three sizes for ordinary lamp socket attachment.

In the installation shown by Fig. 11, Sirocco Mechanical Draft Fans are supplying draft to two of the largest boilers in the world, each of which generates 2,365 horse power.

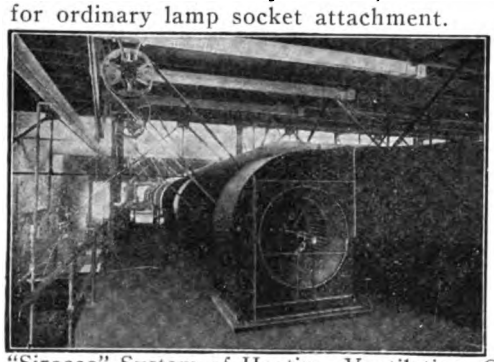
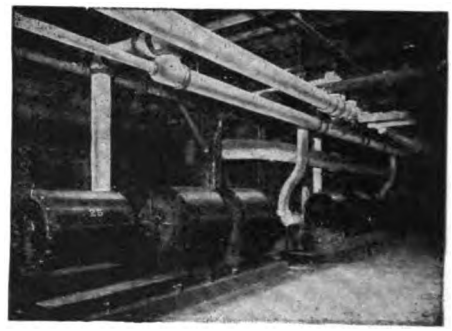


Fig. 4

"Sirocco" System of Heating, Ventilating, Cooling and Drying Installed in Factory Building

Fig. 11



"Sirocco" Mechanical Draft Fan

Fig. 5

Figs. 5, 8, 9 and 10 illustrate several types of blowers and fans. No. 5 is the type "P" Special Steel Pressure Blower, for supplying blast to cupolas and furnaces; No. 8 is the "Sirocco" Multi-Blade Patented Fan Wheel; No. 9 is the type "V" Universal blower and exhauster, which is entirely reversible as to angle of air discharge, with either right or left hand drive, and is built for motor or pulley drive; No.

Fig. 12 is an illustration of the "ABC" Vertical Enclosed Self-Oiling Steam Engine, direct-connected to electric generator. The engine is high speed and of high efficiency. It is specially adaptable for direct connection to fans, centrifugal pumps, stokers, generators, etc.

Fig. 12

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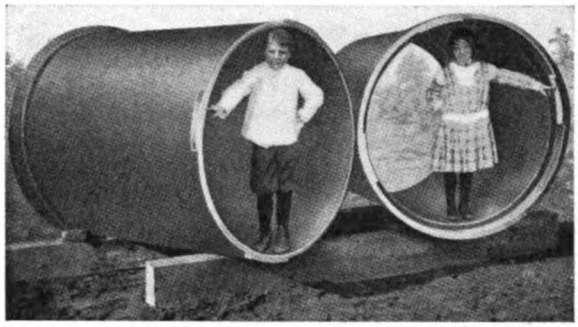
CAST IRON CULVERT PIPE

Cast Iron Culverts

Cast iron culverts constitute a familiar and well established item of railway equipment, this form of construction being among the first to have been employed by railroads in meeting problems of drainage encountered in road-bed maintenance and one which has maintained a prominent place in work of this kind ever since. That they will continue to occupy a prominent place



National Lock-Joint Pipe

is evident because of the many conditions in railway service for which culverts of cast iron are peculiarly adapted. The history of cast iron in culvert service is above all else one of consistent indifference to or stability under such forces as rot, frost, rust and water, which operate to lessen the effectiveness and to shorten the life of sub-surface structures. The extent to which it is used in water mains indicates the degree of reliance placed in its durability, a 24-in. water line in Paris which had suffered but little depreciation during nearly 300 years of use providing an interesting example of this characteristic. With the improvements which have been effected in design, culverts of cast iron have increased in use.

National Culvert Pipe

The culvert pipe manufactured by the American Castings Company, Birmingham, Ala., and known as the National Lock Joint Pipe has contributed in a large way to the prevailing popularity of cast iron culverts. The pipe is the product of a successful effort to meet the large need for a form of culvert construction supplementing the durability of cast iron with such qualities as moderate cost, ease of handling and adaptability to a large range of conditions. It is a pipe of the bell and spigot type which has, as implied by the name, a lock joint feature, is made in short lengths of comparatively light sectional weight, and is designed specially for culvert use. It is manufactured in the following sizes:

Diameter in inches	12″	16″	18″	20″	24″	30″	30″
Length in feet	4	4	3 & 5	3	3	3	3
Weight per foot in pounds	60	80	90	120	160	220	250

Diameter in inches	30″	36″	36″	48″	48″	48″
Length in feet	3 & 5	3 & 5	5 & 5	5	5	5
Weight per foot in pounds	300	345	385	450	510	625

In these pipes the lock joint feature consists of cast iron wedge-shaped keys cast on the spigot and bell of each section and arranged so that by rolling the spigot end of the entering pipe into the bell end of the receiving pipe and revolving it about one-eighth of a turn, the sections are drawn together and locked securely against endwise dislodgement or sagging. The strength of the locking is such that a 30-ft. span of 36-in. pipe, when completely locked, will not sag under its weight. This feature is a highly desirable one where culverts are laid on slopes, upon soft ground, or where it is desired to extend the ends, unsupported, some distance from the bank. The nature of the construction also allows partial locking whereby the culvert can be laid in a curve and still be held against endwise dislodgment. Joints in the pipe are caulked with lead or jute as in pressure pipe, when lead is used, about one-fourth as much being required.

There are a number of points in favor of the use of short lengths in cast iron culvert construction, a prominent one of which is the ease of handling afforded by it. Owing to the short length and relatively light weight of the National pipe a derrick or other expensive equipment is neither required to unload nor to place it. Four men with a track jack and bar can handle the largest sections without difficulty and the smaller sections can be handled without tools. This is a valuable feature inasmuch as the cost of handling pipe from the time of its departure from the factory until it becomes a part of the work is often a determining factor in its use. Other points in favor of the short section are that it can be used with equal facility in constructing the short as well as the long culverts, that it affords a flexibility by reason of which the pipe can be laid in vertical or horizontal curves as readily and effectively as in straight lines, that it avoids the wastage in material encountered where the least number of sections that could be used might make the culvert longer than necessary, and that it reduces loss due to breakage.

The pipes are about 30 to 35 per cent lighter in section than standard pressure pipe but are adequately strong for culvert use, practically no failure in service having been registered against them. In actual service the rib effect afforded by the bells, provides additional reinforcement to the pipe.

48-in. Lock-Joint Pipe "Threaded In" Old Broken-Down Stone Culvert

National Lock Joint Pipe has been on the market over 15 years, and is used extensively throughout the country. That it has been a success in railway service is indicated by the fact that it is now in use on over 50 trunk lines of the country, among which are the Pennsylvania, the Baltimore & Ohio, the Illinois Central, the Great Northern, and the Chicago & Northwestern.

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General

The American Cement Tile Manufacturing Company, Pittsburgh, Pa., is the manufacturer of the American Cement Tile Roofing. This product is the result of an experience with cement tile extending over 30 years and the tile has been on the market about 20 years. It is used extensively on shops, factories, power plants, and public buildings, including many imposing structures throughout the country. It merits the attention of the railroads particularly as a roofing material for machine shops, freight houses, train sheds, depots, and similar railway structures, particularly those of steel construction, for which the tile is specially designed.

American Tile

The tile consist of a metal-reinforced mixture of selected sand and Portland cement formed into a hard, impervious mass by a special process. In this process the tile are given a smooth white undersurface and, excepting for the American Flat Tile, a pleasing and enduring brick-red color on the outside.

The standard sections of the tile are 26-in. wide, 52-in. long and 1-in. thick, and weigh 126 lb. each, or 16 lb. per sq. ft. Each tile has a roll along one edge and an upturned projection or rabbet along the other edge. When placed upon the roof with the roll of one tile fitting over the rabbet of the tile next to it, and elastic cement applied, a water tight joint is provided. The cross joints are formed by lapping each cross row of tile shinglewise over the next lower row about 4-in. and staggering the rows so that the vertical joints in the upper row occur midway between those of the lower row, the face of each tile having a proper ridge at the lower end to fit over the upper 4-in. of the roll of the tile which it overlaps. These joints are also pointed with elastic cement.

The American Standard Tile

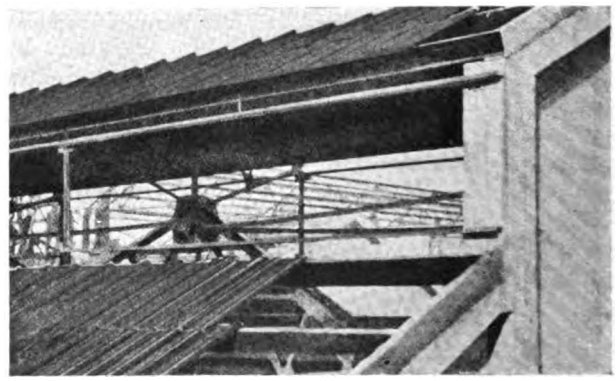
Each tile is held in place by a lip which extends across its upper end and engages the supporting purlin, this lip together with the overlap of each tile and the interlocking at the sides providing adequate fastening, no nailing strip or other similar fastenings being required. The character of the construction also eliminates the need of sheathing or other supports than channel purlins placed on 4 ft. centers and designed to carry 45 lb. to 50 lb. per sq. ft. Expansion in the roofs is provided by the joints. With the underside of the tile white and smooth, water-tight, and protected from sweating by ventilation provided in the roll edge of each tile, this simple arrangement of tile and steel affords an interior sufficiently satisfactory to have been used without other ceiling as the covering of fine pavilions.

The strength of this construction and its resistance to fire have been tested frequently to the satisfaction of building and insurance of officers, both in the laboratory and in actual service. The average breaking load of tile tested at Columbia University, New York, under uniform loading on four-foot spans was 350 lb. per sq. ft., while under tests conducted by the Brooklyn Polytechnic Institute, samples of the tile showed no signs of disintegration during 65 min. periods, at a temperature of 1700 deg. F.

Freight House Roofed with American Tile, P. C. C. & St. L. Ry., Indianapolis, Ind.

Auxiliary to the standard tile, special sections are made for flat roofs, ridges, gable ends, gutter construction, for carrying ventilators, affording flashing around pipes, or providing sky lighting. For roofs having a pitch of less than 1 in 5, the company makes a flat slab, 1½-in. thick, 2-feet wide, and designed to span a purlin spacing of 5 ft. The ends are laid directly on the flanges of I-beam purlins after which the joints are pointed and the entire roof covered with some form of composition roofing. It is of comparatively light weight construction, averaging about 17 lb. to the sq. ft.

For sky lighting a special form of the standard tile is provided which carries a 14-in. by 24-in. panel of ¼-in. ribbed wire glass. This tile eliminates the expensive metal flashing in sky light construction, can be placed anywhere on the roof, and affords excellent light distribution.



A Typical American Tile Roof in Process of Construction

Outstanding points in favor of the American tile roofing are the simplicity of the steel superstructure it affords, its resistance to fire and weather, its water tightness, the practical absence of maintenance cost attending its use, its pleasing architectural appearance, and permanence.

The company maintains branch offices in New York City; Philadelphia, Pa.; Cleveland, O.; and Birmingham, Ala.; and publishes a book of data sheets for designers and builders.

AMERICAN CEMENT TILE MFG. CO., PITTSBURGH, PA.

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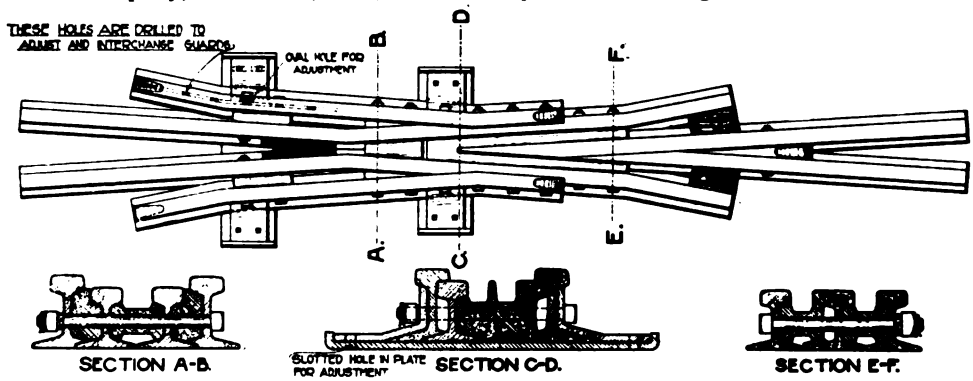
FLANGE FROGS

General

The difficulty in maintaing a correct guard rail gage in yard connections is well recognized by maintenance men. Yard switches are commonly of lighter construction and less securely held in the ballast against the effects of rail creeping than is the case on main lines. While undoubtedly an equal degree of care is employed in placing the guard rails in renewals or when routine adjustments are being made, subsequent movement of the frog has a tendency to disarrange the guard rail gage. As is well known its true measure of correctness is not the distance between the main rail and the guard rail, which can always be definitely obtained by a rigid clamp construction, but the distance from the frog to the guard rail, which is subject to change even between the trips of the trackwalker.

The American Flange Frog & Railway Improvement Company, St. Louis, Mo., has developed the Graham Flange Frog which eliminates the need for guard rails and is recommended for yard tracks operated at moderate speed under heavy as well as light traffic. The device has been employed extensively on a number of roads for more than 15 years where the economy attending its use has become fully recognized. The basic principle of this construction is the addition of flanges or guard rails to the frog itself, which are so located as to guide the wheels securely, insuring that the flanges will always take the proper side of the point.

The cost of the Graham Flange Frog is no greater than that of frogs of the usual construction plus that of two properly secured guard rails. The increased service obtained from these frogs together with a reduced maintenance coupled with entire safety, are causing an extending use of this type of construction in yard work. The ability to control the movement of the wheels independently of the gage of the track is an important point in yard maintenance.



Graham Flange Frog with Sections

The Graham Flange Frog

The Graham Flange Frog is made in two types, the Rail Built and the Solid Manganese Steel with Easer Joint Splice Connection. As best illustrating the principle of the Graham Flange Frog, a cross section is shown for the former type, although under the most severe conditions of service the same results in increased life and attendant economy have been demonstrated for the manganese type as for other forms of manganese construction.

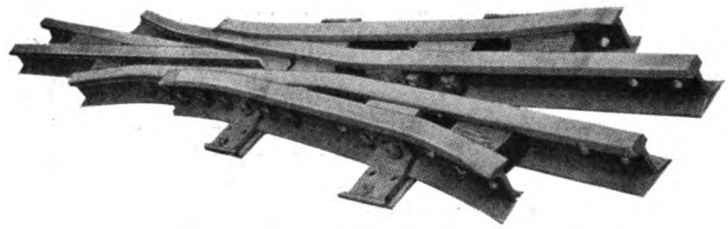
In the design of the rail built type, provision is made for (1) the proper support of the flange rails and their entire stability on the ties, and (2) adjustment, interchangeability and facility of renewal of the flange rails. In both the rail built and manganese steel types the correctness of design, selection of materials and standardization of parts have produced a frog with distinctive qualities of economy.

Solid Manganese Steel Graham Flange Frog

Advantages of Graham Flange Frog

Beside the specific advantages cited for the Graham Flange Frog in conserving both safety of operation and economy in maintenance, through the elimination of the first cost and upkeep of guard rails, a definite saving is effected by the avoidance of the wear and the frequent adzing of ties which frequently accompany the use of guard rails. This is specially important in the case of the long ties at crossovers which are both expensive and difficult to obtain.

The saving of the labor which is constantly necessary to maintain guard rails in correct gage is a further item among the advantages of the Graham Flange frog. Exact track gage in yard tracks is neither necessary nor practicable. Much of the labor about connections occurs through the cutting back of frogs to restore an exact track gage necessary to obtain the proper guard rail gage; or, alternately, the resetting of guard rails to accommodate the guard rail gage to a changed track gage. The use of the Graham Flange frog allows the adjustment of a track gage widened within safe limits to await a seasonable time for its repair, avoiding much loss of labor in making repeated detailed corrections


Graham Flange Frog Rail Built Type

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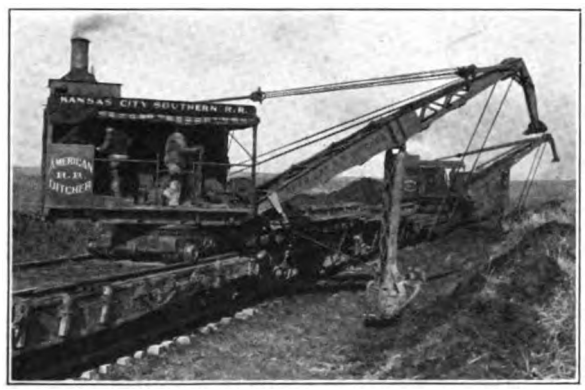
General

The American Hoist and Derrick Company has been for nearly forty years a manufacturer of hoists and derricks, used extensively by the railroads, especially in the maintenance-of-way-department. Among this equipment are hoists for various services, designed for steam, air and motor operation: the "American" derrick engines; derrick cars for many uses; derricks of the guy, stiff leg and portable stiff leg types; locomotive cranes and drag line excavators. The company is however, best known to railway men for its "American" Railroad Ditcher. The company has a large plant and its general offices at St. Paul, Minn., and maintains branches at New York, Chicago, Pittsburgh, Pa., New Orleans, La., Seattle, and Spokane, Wash., and Portland, Ore., while agencies are established in other large cities in this country and Canada.

The American Railroad Ditcher

The American Ditcher is a crane equipped with a steam shovel arm and with additional special features which adapt it to the work of maintenance-of-way ditching. It is a steam-operated machine, efficiently designed and



Double Ditcher Work Train

of rugged construction. The feature which perhaps makes the "American" most valuable for railroad ditching is the fact that the boom can be set to any practical digging depth desired and may be kept there indefinitely. It revolves in a complete circle either way at the will of the operator. The shovel has a trip bottom with an automatic latch, and is so hung as to permit free dumping of the load and positive closing and locking when dropped into the vertical position. The plunger at the boom point is a special feature of the "American," and forces material through the dipper that will not drop out of its own weight.

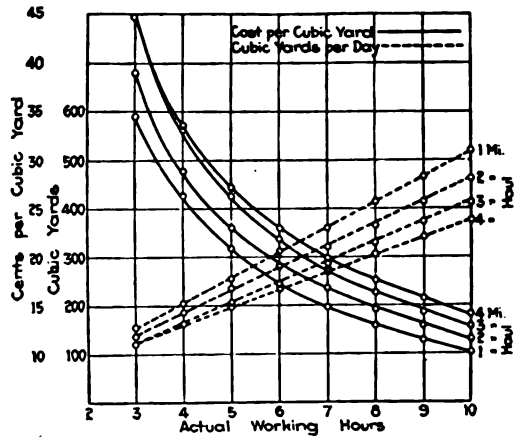
The turntable for slewing the ditcher is of extra strength, yet quick operating and remarkably responsive to the operator's will. It consists of 2 chilled iron beveled paths, with 16 bronze bushed conical steel rollers running between them, and held in place by a spacing ring. The machine is mounted on a solid, single, massive gun-iron casting, heavily ribbed throughout. The machine requires no outriggers, the center of gravity being placed low and safely within the rails, so that it balances at all times regardless of the position of the boom or shovel.

A special feature of the American ditcher is the double-tread wheel arrangement which adapts the "American" to special portable, standard or narrow gauge tracks. This consists of four wide gauge, double-flanged, double-tread chilled wheels, and four auxiliary standard gauge wheels, which can also be furnished for narrow gauge track. The ditcher is designed to dig ditches of any width and depth from 2 ft. deep and 7 ft. 6 in. wide, to 11 ft. 2 in. deep and 24 ft. 3 in. wide.

Ditching with an "American"

There are two methods of ditching with the Railroad Ditcher: (1) with a flat car work train, and (2) with a dump car work train. By the first method, which is the oldest, the "American" travels over its own portable track sections, which it transfers, throughout the length of a train of flat cars, loading them as it progresses, the material being plowed off at the dump with a regulation unloader plow. The newer dump car train method has supplanted to a large extent the flat car work train. This train consists of two dump cars with the ditcher between them, mounted on a 100,000 lb. capacity flat car. This train can be handled by a light locomotive; can clear the track for traffic quickly, and loses no time at the dump. It can be used most effectively where the haul from the cut to the dump does not exceed four miles. As the train can be handled rapidly and requires only a short length of side track to hold it, it can easily be kept out of the way of regular trains, thus causing no interference with traffic, and, at the same time, keeping the time lost in clearing for trains down to the lowest possible figure.

With the diagram shown, it is possible to estimate with accuracy the amount and cost of the work that can be done in this way with a train having one "American" ditcher and two side dump cars. The diagram is prepared for ditches from 2 to 3 ft. deep, while the excavating capacity is placed at 60 cu. yd. an hour, the train speed at 20 miles an hour, and the distance to the dump or switch 2 miles.



The daily cost of the work train, including wages, fuel, oil, interest and depreciation, was taken at $53.76, although it should be understood that these figures were compiled on the basis of conditions existing several years ago, and should be revised for present rates of pay for labor.

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DITCHING MACHINE

When digging a ditch 2 feet deep and actually working 6 hours a day, the daily yardage should be not less than 280 cu. yds. During November, 1917, the Southern Railway's "American" Railroad Ditcher, working on the Coster Division, maintained for 25 days a daily average of 623 cu. yds., of material taken out of the ditches, dumped on fills, and leveled off. The "American" was used between two dump cars, which were dumped by hand, there being a laborer on each car for that purpose.

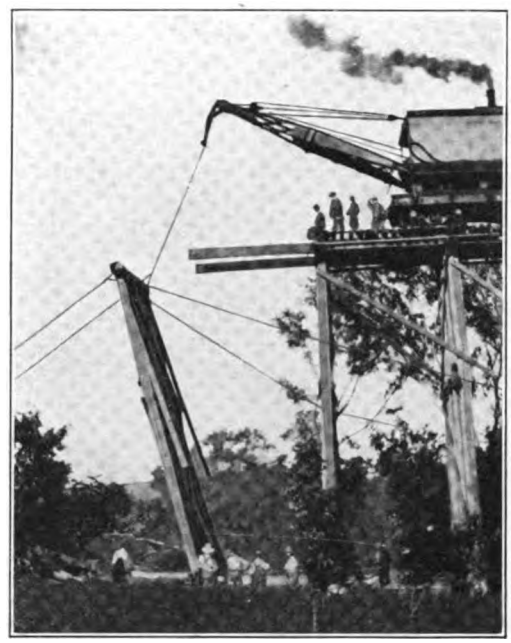
Auxiliary Uses of the Ditcher

In addition to ditching there are many other kinds of maintenance work of nearly equal importance, in the performance of which the American Railroad Ditcher is capable of rendering valuable service. Steam shovel work is a common requirement at borrow pits for earth filling, at gravel pits and disintegrated granite quarries worked for ballast supply, and at other similar places, and at such points the American, in spite of its smaller shovel capacity, has proved itself useful equipment. Under some conditions it has even demonstrated decided advantages over large shovels. It can make more passes per minute than a large shovel; slews in a full circle; and can dig or dump at any point within this circle. It does not require more than one or two pit men, and can move ahead on its own portable track sections in seconds where a large shovel requires minutes. The "American" also has a decided advantage over a large steam shovel when working against a light face. It often spots its own cars, making it unnecessary to keep a locomotive in constant attendence. It has dug and loaded disintegrated granite for as low as 4.6 cents

Ditcher on Steam Shovel Work

a yard, under the labor rates prevailing a few years ago.

The American Railroad Ditcher also has distinct uses in the bridge and building department. Equipped with a standard set of 30 or 40-ft. leads it becomes a pile driver of marked speed and flexibility. It is not unusual for it to drive 8 or 9 three-pile bents a day and to place all caps and stringers. As a "B. & B." traveler for erecting and tearing down timber trestles and bridges of timber or steel, it has the advantages of mobility, speed and comparative lightness. In addition, it has ample power for all but the very heaviest work that comes under this classification. Its fitness for this work is well illustrated by the record it made when rebuilding a high timber trestle at Lawrence, Neb., on the Missouri Pacific. At this place it did in 4 days, work which would have taken 30 men 8 days. Not only that, it also cut the cost 40 per cent under the estimates.



Ditcher Building a Trestle

The occasional uses of the American ditcher in the track department are often those of immediate importance in railway operation. It is a handy machine for cleaning up slides, its advantage over the steam shovel at this kind of work being particularly marked when the work has to be done in cramped quarters. In a narrow, single track cut, where the digging is straight ahead and the material has to be dumped into cars on the track behind; an "American" will work almost as fast as if dumping into cars on a passing track.

The American ditcher is also useful equipment for many of the routine items of maintenance work other than ditching. In the handling of rails, either loading or unloading, an "American" will take the place of a gang of 25 or 30 men, and will handle a greater number of rails in much less time. Besides, the "American" will do away with the troubles which attend the employment of large gangs of laborers, accidents to the workmen, damaging of the rails, injury to the ballast shoulder, etc.

The "American" is also useful in handling all other track materials quickly, safely and economically. The Vandalia R. R. has unloaded 100-lb. steel rails with an "American" at an average rate of 100 rails an hour. It has unloaded as many as 97 rails in 40 minutes, about a thousand rails a day being a fair average.

The Atlantic Coast Line has loaded ties with an "American" Railroad Ditcher at the rate of 650 ties an hour, averaging 3900 ties in a 6-hr. working day.

Other Auxiliary Uses of the "American" Ditcher are: Grading for track, coal handling, placing riprap, light wrecking, locomotive crane work, raising track, snow handling, setting poles in place, driving stubs to reinforce poles that have begun to rot in the ground, building roads, and clamshell work.

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General

Manganese steel castings were originally made in a small way in England and were subsequently produced for the first time in the United States in 1892. The growth of this particular sub-division of the steel founders' art has been very rapid, the annual capacity in this country alone now exceeding 60,000 tons.

Manganese steel as made by the American Manganese Steel Company, one of the pioneers in the industry and now one of the largest manganese steel founders in the world, is a special converter metal to which a quantity of ferro-manganese is added in the ladle. The metal thus produced has the combined qualities of toughness and hardness, which make it specially valuable in service where there is severe abrasive wear.

Manganese steel castings are used for a great variety of purpose, including parts for steam shovels, crushers, dredges, grab buckets, concrete mixers, cranes, lifting magnets, gears, pinions and other vital parts of almost every class of machinery. The material is used extensively in elevating and conveying installations demanding high resistance to wear and breakage. It has established a definite function in track work for the parts of frogs, switches and crossings subject in the greatest degree to the impacts of heavy traffic.

The products of the American Manganese Steel Company are mainly sold under the trade name "AMSCO", although the name "Stag" will continue to be used in certain lines of the manganese steel output. There is no difference in quality between products bearing the one name or the other, both brands standing for the same high grade of manganese steel castings that have been developed by an organization engaged actively in the manufacture since its inception in this country.

The American Manganese Steel Company's executive offices are at Chicago. Its foundries are at Chicago Heights, Ill., New Castle, Del., and Oakland, Calif. The general sales office is at the Chicago Heights plant and district sales offices are maintained in New York; Chicago; Pittsburgh, Pa.; Minneapolis, Minn.; Salt Lake City, Utah; San Francisco and Los Angeles, Calif.; Seattle, Wash.; Portland, Ore.; and New Castle, Del. Canadian representatives are at Vancouver and Nelson, B. C., and at New Liskeard, Ont.

Manganese Steel Castings

Fig. A shows ordinary open hearth low carbon steel, after it has been subjected to abrasion with some metal of a higher carbon content or greater tensile strength, as it appears through a magnifying glass of 40 diameters. The sharp points have been bent over and then torn off, the tearing off being made possible by the lower tensile strength of the abraded material. This breaking off of the sharp points, which in use is going on continually, is called wear.

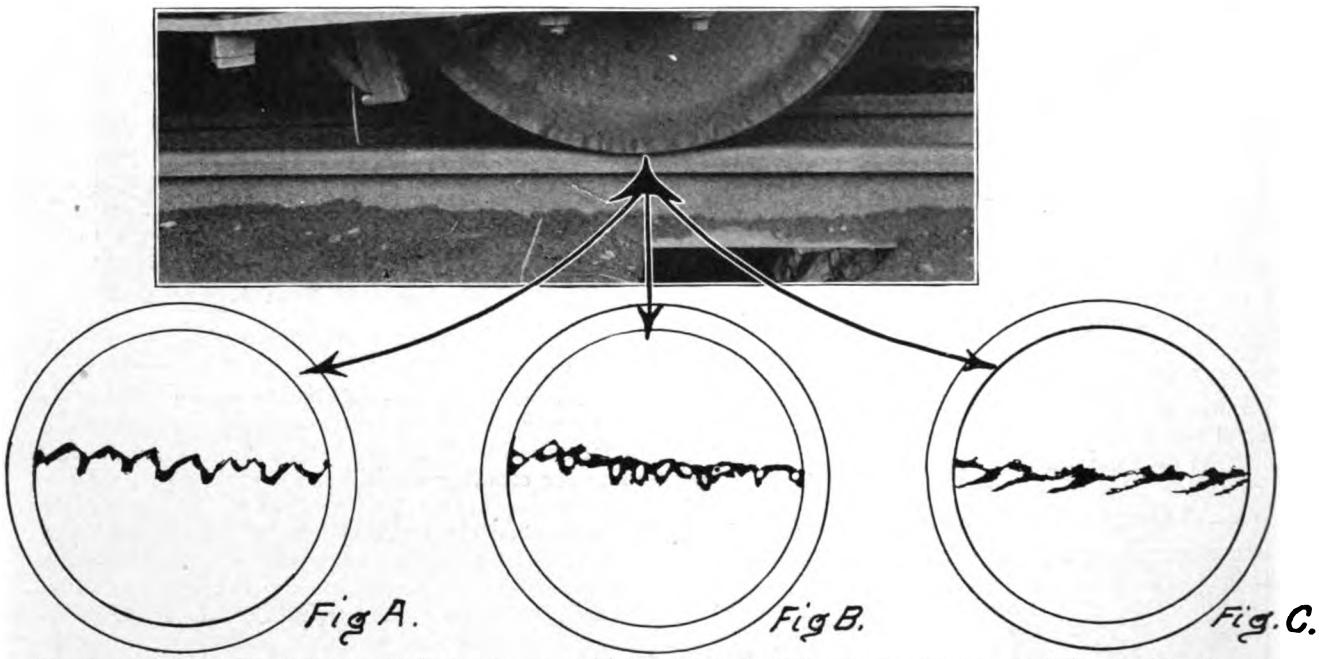

Fig. B shows a hard steel under the same conditions as in Fig. A. Here the metal seen under the glass is brittle and hard. It snaps off and the broken piece falls into a valley in the metal, forming a grit which cuts into the metal, forming more peaks to be broken off and cause wear.

Fig. C shows manganese steel under the same conditions as in Figs. A and B. The ductility of the metal allows the peaks to bend over easily, and its high tensile strength prevents its being torn off. The peaks bend over and fill the valleys, thus causing the smooth and polished surface which appears even under the magnifying glass.

Although fundamentally similar to ordinary steel foundry practice, the successful production of manganese steel castings involves a number of factors not vital in ordinary work. As manufactured at present manganese steel is similar in analysis to ordinary converter metal except that it is high in carbon and unusually high in manganese.

As manganese steel comes from the sand it is almost as hard and brittle as glass and must be made ductile by a heat-treating process. The necessity for heat-treating limits the thickness of sections which can be cast successfully in manganese steel, although research carried on during the last few years has resulted in a gradual increase in the possible thickness of the castings, those having walls 4 in.

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thick being now heat-treated successfully.

The shrinkage of manganese steel is excessive, amounting to 5/16 in. per ft., as against 3/16 in. to ¼ in. in ordinary practice. While allowance for shrinkage may be made in the patterns, the problem also extends to the distribution of the metal in order that the strains produced by the heat treating and the cooling may be taken care of. The entire process of manufacture is one which requires special experience, particularly in the melting and mixing of the metals and the heat treating of the castings.

AMSCO Manganese Steel in Track Work

Manganese steel track structures have amply demonstrated their durability under severe service conditions. Rail-bound manganese frogs, installed in tangents in high speed main lines as early as 1903, are reported as still in the track and in good condition. In the curved connections of terminals many manganese steel frogs have had a life equal to that of 25 frogs made of Bessemer steel.

The use of AMSCO Manganese steel in track work has demonstrated not only increased economy but a higher degree of safety. The disadvantages and even danger in any complicated work from irregular wear of the members receiving variable thrusts, are items making for the use of hardened metal in all track members where excessive wear takes place. In main line connections, and even in the leads through busy yards, the use of manganese steel construction in frogs and crossings and as tips for the points of switches, is receiving consideration by reason of the increased safety afforded.

The advantages of manganese steel rails at point of severe wear are now recognized and one important road about the close of the year 1920 placed an order for 2,000 tons of this material.

AMSCO Steel in Shovels and Dredges

It is a well known fact that all manufacturers of steam shovels and dipper dredges have been making manganese steel a part of their standard equipment. The application of AMSCO manganese steel to the wearing parts of these machines has aided in the solution of the economic problem by insuring continuous operation. Relatively, first cost is of secondary consideration to cost of operation, and therefore the best of material has to be used for the parts of greatest wear.

The superior qualities of AMSCO has broadened its field to include the following parts of shovels and dredges: solid dippers; fronts, of the plain and Vanderhoef type; teeth, of the solid and two part type; dipper lips and bottom-bands; racks and shipper shaft pinions; bails and bail brackets; latches and latch keepers; doors and hinges; revolving rails and trunnions; gears and pinions; rail clamps; and propeller chains and sprockets. AMSCO manganese steel has demonstrated, over a period of years and in every conceivable kind of digging, the advantage and economies of this "toughest of known steels."

AMSCO Steel in Ballast Crushers

The wearing parts of ballast crushers require a wear and shock-resisting metal of an extraordinary kind. AMSCO manganese steel, by reason of its toughness, strength and resilience has proved to be a metal well adapted for this purpose. The hardest trap rock can be handled without difficulty if the crusher is fitted with parts made of the metal. The demand on the part of users of crushers has led many of the manufacturers to market their machines already equipped with AMSCO brand manganese steel parts.

AMSCO is recommended for the following parts of crushers: movable jaw plates, stationary jaw plates, cheek plates, toggle or adjusting plates, toggle bearings and chutes. Jaw plates of this material wear from four to six times as long as chilled iron plates and do not chip or pocket. On account of the greater strength and toughness of the metal the teeth are made considerably sharper than those of cast iron plates. The still longer service obtained for the cheek plates and the toggle plates and toggle-bearings when of AMSCO manganese steel, makes the use of this metal an important one in lessening cost and annoyance in crusher operation.

AMSCO Steel in Elevating and Conveying

An abrasive action is generally present in the elevating and conveying of materials and it is recognized that manganese steel possesses a remarkable resistance to such action. Fewer renewals and less expense incident to breakdowns are claims made for AMSCO which past performance fully justifies.

From the maintenance viewpoint the principal product in this line is the AMSCO manganese steel elevator buckets used for handling crushed stone, coal, ashes or other bulk materials. This equipment has proved not only dependable but economical in this service.

The AMSCO elevator buckets are generally required in the Style A type, which is specially adapted for handling fine material, although the Style A A, which is similar but with heavy reinforced front, edges and corners, is preferable when heavy, coarse, abrasive materials are to be handled. The continuous style of buckets are desirable in some services and these are cast in one piece. The buckets may be supplied promptly in all practical sizes.

AMSCO Engineering Service

There are many other common applications of AMSCO manganese steel to the structures and machines used in maintenance, such as for grab bucket sheaves, various types of detachable link chain and sprockets, pins, bushings, etc., and the number is constantly being increased as the utility of the material is becoming better appreciated.

The company maintains engineering bureaus to cooperate with the railroad officer with a view to overcoming trouble due to the rapid wear or breakage of any of the vital parts of machinery or equipment. While the use of manganese steel in track work is well established its employment in machinery and for track and signal structures, such as draw bridge locks, etc., well may be extended. As additional experiments increase the practical depth of annealing a wider field will be opened for the use of manganese steel in railway service, and the engineering bureaus of the American Manganese Steel Company are prepared to render advice and assistance in this development.

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General

In no other industry is the problem of resisting the ravages of rust so insistent as on the railroads. Their metal structures are subjected to the most extreme conditions as regards corrosion. That the gases from the locomotive cause severe corrosion is indeed well known, its acceleration from this cause being due to the sulphurous gases, moisture, and the carbonic acid gases which are produced as products of combustion.

While the loss of metal from corrosion is of considerable importance, a still more serious aspect is presented on account of the attendant inconvenience

Bridge with Chains 100 Years Old

and expense of making replacements. Therefore, the use of a metal having maximum rust-resisting qualities is essential for those permanent structures to which the metal is adaptable, and also for the more modern types of railway equipment.

Many years ago prominent scientists proposed the electrolytic theory of corrosion, and it was suggested that if a perfectly pure and homogeneous iron could be produced it would retard corrosion, especially by causing the corrosion to occur over the entire surface instead of by pitting, the latter form of corrosion taking place where the impurities have segregated.

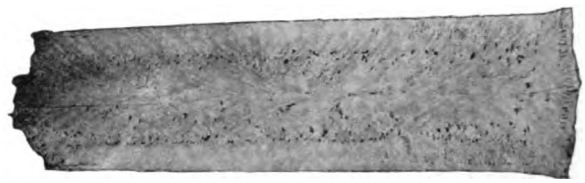
In the research laboratory of the American Rolling Mill Company, many samples of old irons have been analyzed and examined, some of these irons having a known life of 16 centuries. It is common knowledge that the pure iron made 100 years ago was more durable than is modern steel. Links of iron, for instance, which composed the chains of a suspension bridge near the coast of Massachusetts, showed no appreciable corrosion after having been exposed to the salt air for more than 100 years. It is well known that chains are subjected to more severe conditions from a corrosion standpoint than almost any other ferrous metal. This is by reason of the fact that no protective paint or other coating can be applied where the links are jointed, and thus the metal lacks protection at those points. Pure iron nails, found in a grave where they had been buried for 100 years, analyzed 99.83 per cent iron, and were in an excellent state of preservation.

In 1905, Dr. A. S. Cushman, who was then with the Department of Agriculture, suggested the manufacture of a low manganese iron to be made in an open hearth furnace. The American Rolling Mill Company of Middletown, Ohio, began experimenting upon, and finally Dr. R. B. Carnahan produced, a pure iron, made in an open hearth furnace, which is known as "Armco" Ingot iron, and which contains 99.84 per cent iron by difference, when considering not only the sulphur, phosphorus, carbon, manganese, and silicon as impurities, but also copper and the gases, oxygen, hydrogen, and nitrogen. This iron is even purer than the best brand of Norway or Swedish iron.

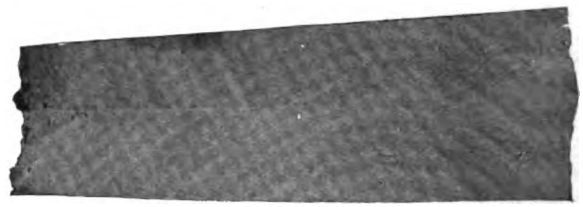
Chemical Properties of Armco Iron

In 1910, the American Rolling Mill Company built and equipped a modern research laboratory for the purpose of investigating the properties of iron and iron alloys from every standpoint. In the investigation of corrosion problems it was soon found that nitrogen played an important part, and that all ferrous metals containing a high nitrogen content had a short life when exposed to general service conditions. It therefore became the policy of the American Rolling Mill Company to keep the nitrogen content in its product as low as possible, and the uniformity with which this is accomplished can only be understood when it is considered that the range of nitrogen in "Armco" Ingot iron is between 0.003 and 0.005 per cent. This is extremely low, especially when compared with the nitrogen content of steels which have corroded rapidly under general service conditions, such steels running as high as .045 per cent, or ten times as much as the average nitrogen content of "Armco" Ingot iron.

The American Rolling Mill Company found it necessary to make a very careful selection of all raw materials, as it was seen to be impossible to make a uniform product without first knowing the analysis



Ingot of Steel Sawed Through



Ingot of "Armco" Ingot Iron Sawed Through

of all the materials entering into its manufacture. It was considered essential to limit the sulphur content of the coal, since it was found that the sulphur in the producer gases used in the melting operations increased the sulphur content of the metal. Very rigid limits are therefore placed upon the maximum sulphur content of any coal used in the metallurgical operations of the American Rolling Mill Company.

Physical Properties of "Armco" Ingot Iron

In its physical properties, "Armco" Ingot iron is soft, ductile, and easily worked. In the forging of "Armco" Ingot iron it has been found profitable to work it below 800° C. If worked above 800° C., there is danger of the

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metal checking, although this checking is not encountered above 1000° C. It is therefore only necessary to avoid working the metal between 800 and 1000° C. The critical temperature for working "Armco" Ingot iron is a peculiarity of all pure metals, all being unworkable at certain temperatures. "Armco" Ingot iron has high electrical conductivity, which is approximately 50 per cent greater than the conductivity of steel. It also has a low magnetic retentivity, which makes it desirable for conditions where the quick release of the electric current is desirable, as in magnets.

Galvanizing and Enameling of "Armco" Ingot Iron

Considerable research work has been done on the effect of protective coatings, and it has been ascertained that a pure zinc coating is more resistant to corrosion than an impure zinc coating. It has also been found that "Armco" Ingot iron, on account of its high purity and density, does not contaminate the zinc or spelter coating applied in the galvanization of sheets, and that therefore the coating on "Armco" Ingot iron is more rust resisting under general service conditions than a galvanized coating on impure and spongy steel. It has been discovered that pure iron is much less soluble in molten spelter than steel, and therefore the spelter bath is not contaminated with iron to the same extent when pure iron is galvanized as when impure steel passes through the spelter pot.

"Armco" Ingot Iron Corrugated Sheets

The fire proof characteristics of sheet metal and the corrosion resisting quality of pure iron make "Armco" Ingot iron corrugated sheets of special value for building purposes. They are light and durable and permit the employment of a light, framework for the building. They are furnished either painted or galvanized for use as roofing, siding, ceiling, etc. One of the great advantages of corrugated roofing and siding is its ease of application to skeleton framing, thus insuring a low cost along with a durable and effective construction. The sheets are also made in shapes suited to end wall or side wall flashing.

"Armco" Culvert Under High Fill

"Armco" Ingot iron sheets in the form of arches, are much used in bridge flooring as a support for a roadway surface. They are strong, light, fireproof, mechanically correct and low in cost. The corrugations act as beams in themselves, and the construction in the form of an arch furnishes the maximum of strength for the amount of material employed. In fireproof buildings they likewise form an excellent ceiling and a foundation for the floor above. These arches are manufactured to specifications furnished, and are guaranteed to fit according to the working plans.

"Armco" Arches in Bridge Floor

"Armco" Ingot Iron Blue Annealed Sheets

The condition about the railroads which is most active in promoting corrosion is of course moisture, but coal gases play a prominent part, especially in structures exposed to their direct action, like the smoke guards under overgrade bridges. That old irons resisted corrosion in railway use as elsewhere is shown by the service of four iron tanks on the Louisville and Nashville, which were built in 1870. A stand pipe erected in 1872 is still in service, having been painted only five times in the 28 years. "Armco" Ingot iron plates and sheets, made of pure iron will give even better service than these old irons.

"Armco" Ingot iron, fabricated into railway structures, insures a long life under the most exacting conditions. Its most important uses, other than for the construction of locomotive tenders and smoke stacks, and box and gondola equipment, are: for track structures; for smoke jacks in round-houses; for lining the storage bins in locomotive coaling stations; for tanks, towers and water troughs in water facilities; and, generally in railroad service, for oil, gas, water and underground storage tanks. A particular feature of "Armco" Ingot iron for most of those uses is the facility with which the metal will take and hold paint.

"Armco" Wire Rods and Wire

In no other railway field is the adaptability of "Armco" Ingot iron more pronounced than in that of wire products. Its peculiar characteristics of rust-resistance, electrical conductivity, magnetic property and welding quality adapt it to right-of-way fencing, transmission lines, telephone and telegraph wire, bond and signal wire, welding wire and many similar uses in maintenance.

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General

The shortage, high prices, and delayed deliveries which have led, and in many instances, forced the railroads to give attention to programs of conservation and waste prevention in various lines of activity have correspondingly encouraged the development and introduction of devices and appliances calculated to increase the useful life of materials. These conditions have operated to make it distinctly profitable for the railways to employ saw mill machinery in the maintenance field.

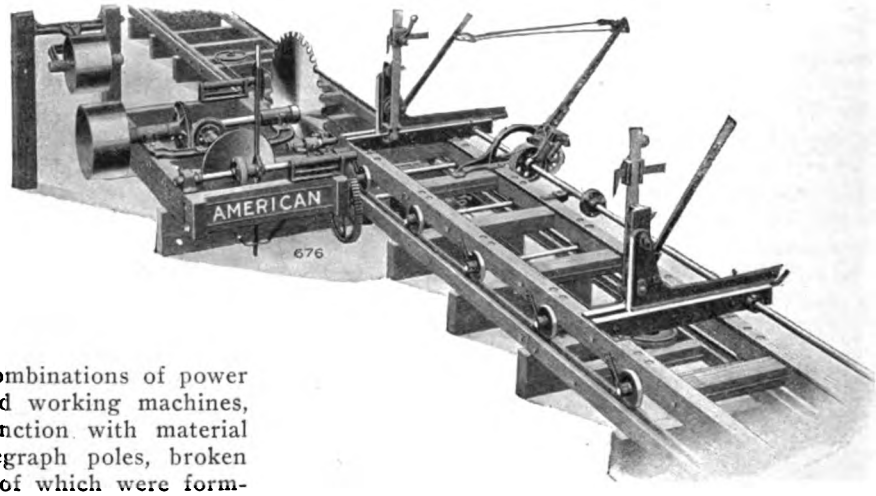
Throughout the country millions of feet of dimension timber in bridges, culverts, docks, snow sheds, etc., is being released in routine repair and replacement work. Saw mills provide an economical means of reclaiming this timber and utilizing it to the best advantage. Thus, it may be possible to saw the ends off timber otherwise sound and use it again in its original form, while other timber, either too large or too valuable in the original form for work of other kinds, may be sawed to smaller dimensions. Similarly, by means of temporarily or permanently located combinations of power saws, planers, and other wood working machines, operated alone or in conjunction with material yards, etc., pile cut-offs, telegraph poles, broken timbers, or even old ties, all of which were formerly destroyed, may be converted into posts, rails, boards, blocking, wedges, and even made into shingles and jack handles, which must otherwise be taken from new stock. Plants which are turning over 200 per cent on the investment indicate the possibilities of such programs. Again, employed judiciously in connection with the repairing or renewing of structures, and on the smaller platform or crossing jobs as well as the construction of stock yards, tunnels, culverts, bridges, and buildings, suitable machines often provide the means of greatly reducing costs, of getting satisfactory results with short-handed crews, of releasing a crew more quickly for other pressing work, or of speeding up emergency work.

The "American" Company

The plant of the American Saw Mill Machinery Company at Hackettstown, N. J., is the largest in the United States devoted exclusively to making portable saw mills and companion machines. Hackettstown is but fifty-seven miles from New York City and is advantageously situated with respect to sources of raw materials, and transportation. The plant is modern, and is provided with facilities for the production of high grade equipment economically. Its products include the Cordesman-Rechtin line, formerly made by the Enterprise Mfg. Co., Columbus, O. They are used extensively at home and abroad in lumber camps and factories, by contractors, industrial concerns, and railroads. During the war, 2,000 "American" power saws alone were employed in the forests of France, in ship-yards and war supply plants, and in the construction of military camps. In addition to their extended service records, all "American" machines are backed by a guarantee covering materials, workmanship, and operation. "American" distributing agencies are located in practically all the principle American cities.

No. 2 American Saw Mill

Of the many types of power saws manufactured by the American Saw Mill Company, the No. 2 American Portable Saw Mill is adapted particularly for converting piling and large bridge timbers into dimension lumber. The mill complete consists of a power-operated circular



American Saw Mill No. 2

saw, a travelling carriage, a supporting frame work or body, and mechanism for operating the saw and carriage and for setting and holding the logs. With the exception of the machinery it is built entirely of selected Southern yellow pine or other hard wood, mortised and tenoned where needed and thoroughly braced and bolted, and, to operate properly, is set low to the ground on cross sleepers. That part of the body known as the ways or runway for the carriage is 56 ft. long, is made in two sections for convenience in handling, and carries 40 ft. of steel track, 20 ft. of "V" shaped on one side and 20 ft. of flat on the other. The husk frame, that part of the body supporting the saw mandrel and friction feed machinery, is 7 ft. 6 in. long, and 3 ft. 6 in. wide, and is built of 3½ in. by 9½ in. timber.

The carriage is 20 ft. long, and 30 in. wide, and is built of 3½ in. by 5½ in. timber. It is mounted on six trucks each, consisting of two 7-in. wheels, the 1¼-in. axles of the trucks working in self-oiling boxes. The wheel tracks are kept cleaned by scrapers fastened to the carriages ahead of each wheel. The carriage is equipped with two head blocks, equipped, in turn, with "Champion" duplex dogs, and with the company's "Ideal" set works and quick receder. All three devices are joined by a 16-ft. set shaft so connected to the head block as to eliminate trouble from faulty alignment. The head blocks open 38 in., the movement of both head blocks toward and away from the saw being effected

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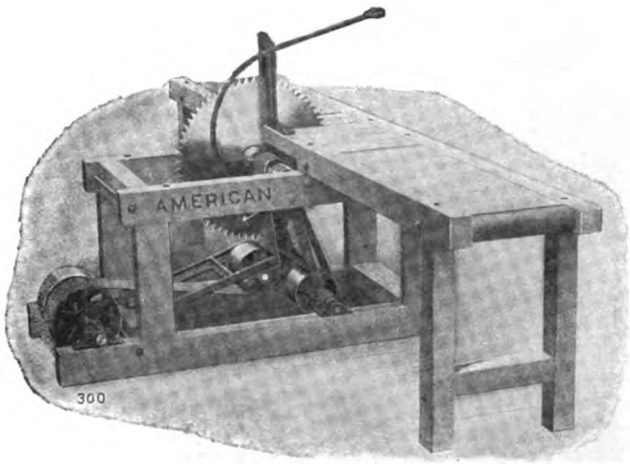
simultaneously by the set works. The dogs on the head blocks are forced into the timber by pressure on a lever. The set works operate on the rachet principle, both the advancing and receding movement being accomplished by pulling on the lever, which is accessible from the sawyer's stand. It is so designed that three or four pulls are sufficient to throw the head blocks back their full distance.

The variable speed friction feed, by means of which the carriage is operated, consists of a system of discs which, when brought in contact, transmit the motion of the saw mandrel through gears to



American New Model Cut-off Saw

the winding drum and wire cable of the carriage. This feed is simple and powerful. It responds to the slightest pressure of the feed lever. The sawyer has absolute control of the carriage with one hand at all times and can vary the feed instantly to suit the size of timber and reverse the motion of the carriage as quickly. The saw mandrel is of steel, $2\frac{5}{16}$ in. in dia. and 60 in. long. It is made to take any saw with standard holes, revolves in chain-oiled boxes, and is fitted with a 20 in. by 10 in. pulley. The machinery includes an adjustable saw guide, and a belt tightener, and the mill is equipped with various accessories.

The mill will take any size of saw up to 54 in., can be operated by any power from 10 to 20 horsepower and will cut logs 45 in. in diameter. Its rated capacity for 10 hr. with a 20 horsepower engine is 10,000 ft. of board lumber. The mill weighs about 3,650 lb.

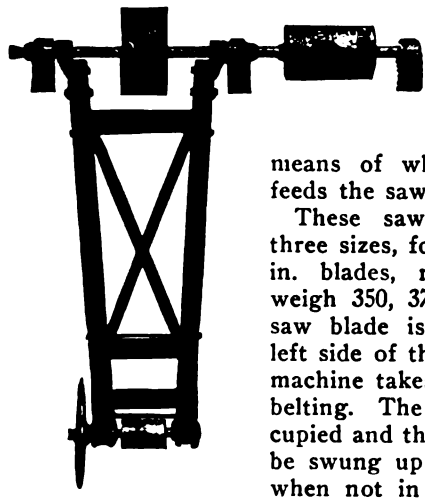
Cut-off Saws

No saw mill is complete without a cut-off saw, either of the table or swinging type. The employment of such a saw is particularly valuable in a railway timber reclamation plant or material yard where the bulk of the work usually consists in the sawing of stock lumber in shorter lengths or cutting off bad ends of second hand material. The American New Model cut-off saw is of the table type and is designed to meet the large demand for a heavy and powerful saw for general use. This saw will handle any lumber from boards up to 6 in. by 14 in. dimension stock. It consists of a cut-off table and saw frame, is built of Southern yellow pine or other hard wood well braced and bolted, and accommodates a 30-in. saw.

The table is 20 in. wide, and 12 ft. long, is made of 3½ in. by 3½ in. timber, and is fitted with four 4-in. rolls and, at the rear, with a substantial guide rail. The saw frame is built of 3½ in. by 5½ in. timber, is carried on the free end of a cast iron swinging frame and is drawn forward against the timber by an iron handle safety accessible from the front of the table. The saw mandrel is of cold-rolled steel, revolves in babbitted boxes on the swinging frame, and carries a 4-in. belt pulley. The countershaft carries two 12 in. by 6 in. pulleys and is placed well back on the base of the frame, thus permitting the use of a long drive belt. An idler pulley on a separate swinging frame keeps the belt tight. This machine allows a speed of 1200 R. P. M. in the saw. For service requiring the cutting of timber up to 15 in. by 15 in. the company manufactures this table in a heavier type.

Swing Cut-Off Saws

A swing type of cut-off saw can often be used to distinct advantage on temporary jobs, in portable plants, or where it is inconvenient or unnecessary to employ the table type of cut-off saw. Of the several styles made by the American Saw Mill Machinery Company, the wood frame saw is usually adequate for railway needs and is the least expensive. This machine consists of a circular saw mounted on the swinging end of a wood frame suspended from overhead shafting. The frame is of hard wood, well braced and swings on iron hinges bolted to the frame. The saw mandrel is supported by a yoke casting bolted to the end of the frame, and carries a 6-in. pulley between the two bearing boxes, and directly in line with a pulley on the overhead shaft. The mandrel yoke is provided with a grab iron by means of which the sawyer feeds the saw into the timber.



Swing Cut-off Saw

These saws are made in three sizes, for 30, 36, and 42-in. blades, respectively, and weigh 350, 375, 450 lb. The saw blade is carried on the left side of the frame and the machine takes about 15 ft. of belting. The small space occupied and the fact that it can be swung up out of the way when not in use are distinctive features of this machine. The saw can be secured to overhead timbers, wall brackets, or upright posts as desired. It is thus a machine which can be carried in an outfit car and set up readily in any place.

Combination Rip and Cut-Off Saw

The value to a railroad of a machine in which a rip saw, a cut-off saw, and the necessary operating power are combined in an arrangement which can be moved without difficulty from place to place and be set up or dismantled quickly is obvious. This is accomplished in the

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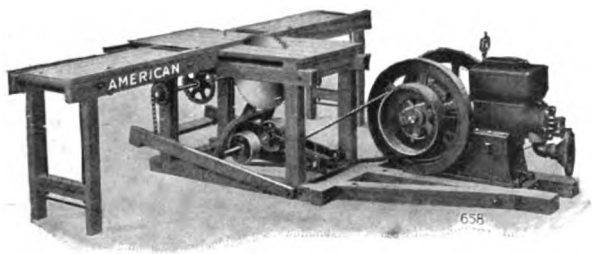
American Combination Rip and Cut-off Saw. In this type of saw the base of the saw frame is extended backward to provide a foundation for a 5 or 7 horsepower gasoline or kerosene engine or motor. On the top of the frame is mounted a ripping table extending lengthwise in the direction of the saw. The ripping table and two extension tables, extending to either side of it, being fastened to it at one end and supported by legs at the other, form the cut-off table. The saw is carried on a cast iron swing frame fastened to the base of the saw frame and for cut-off work is drawn forward by a substantial wood foot treadle, the motion of which is transmitted to the swing frame by means of sprockets and chains. The saw recedes by its own weight. When ripping, the swing frame is locked securely in a fixed position. The drive belt is connected directly with a pulley on the gas-engine crank shaft and is kept tight by an idler pulley on a separate swing frame.

These saws are made in two sizes. In size No. 1, the length over-all is 10 ft. 4 in.; the width, 9 ft. 7 in.; the ripping table, 27½ in. by 54 in.; the width of extension tables, 20 in.; the size of the rip saw and cut-off saw, 20 in.; the weight without engine, 800 lb.; the size of cut-off, 6 in. by 6 in. timbers, or boards up to 16 in.; and the depth of ripping, 6 in. In size No. 2, the length over-all is 15 ft. 8 in.; the width with engine, 10 ft.; the ripping table, 36 in. by

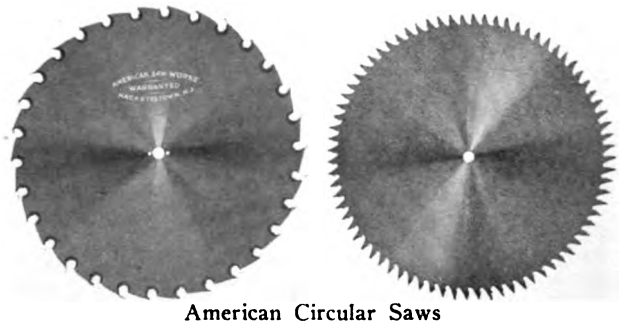


Combination Rip and Cut-off Saw

58 in.; the width of extension table, 23 in.; the size of rip and cut-off saws, 30 in.; the weight without power, 1,100 lb.; the size of cut-off, 10 in. by 10 in. timbers, or boards and planks up to 16 in.; and the depth of ripping, 10 in. The tables for both sizes are 34 in. high. The extension tables are equipped with two rolls each and can be detached and the legs collapsed. Guide rails are supplied which may be used on the rear or front sides of the extensions for cut-off purposes and a steel guide is provided for ripping which is adjustable to any position on the table and is secured by a clamp screw in front. The wood of the machine is of Southern yellow pine or other hard wood, well braced and bolted.

The American Saws

Obviously the saw itself is a most important element of the machine of which it forms a part and upon its performance largely depends the success of the installation. A tendency to wabble under high speed and to bind, failure to hold its cutting edge, or a tendency to crack and fly in pieces, are sources of continual annoyance, expense, and danger. It is particularly important to employ a trustworthy saw and one which can be repaired in timber reclamation work owing to the

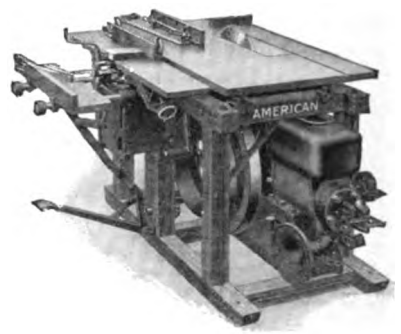


American Circular Saws

likelihood of striking spikes and bolts in the lumber accidentally. The saws made by the American Saw Works, a subsidiary of the American Saw Mill Machinery Company, are of the best obtainable material and are tempered and worked by saw specialists. They are made extra tough and are fully warranted to be true and free from flaws. The company makes and repairs solid tooth saws for all purposes of either standard or special design, and in all sizes and gauges. It makes several types of inserted tooth saws, of which its No. 2½ saw is especially adapted to heavy feeds, hard wood, and frozen timber. Its No. 3 saw is adapted for all general sawing in soft or hard wood, and its No. 4 is recommended for cutting soft Southern or Pacific coast timber.

Other American Products

Other products of the American Saw Mill Machinery Company which can frequently be employed to advantage in the railway maintenance field are the Contractors' Portable Variety Wood Worker and the American Hand Planer. The Portable Wood Worker is built of wood and consists of a rip and cut-off saw bench, with boring attachment, hollow chisel, mortiser, and 8-in. jointer. The machine is compactly arranged and is furnished with or without an attached 5 horsepower engine or motor. This machine is designed to handle a large variety of light or medium mill work and is intended to be used in connection with building projects or in the shop.



Variety Wood Worker

The American Hand Planer or Jointer is designed for all kinds of planing work and is intended for use in wood working shops. It consists of two adjustable iron tables and a four-knife cylinder head, mounted on a cast pedestal. The tables are strongly ribbed, planed perfectly true, and are arranged for babbiting. The machine is made in three sizes, for 12-in., 16-in. and 20-in. knives. The tables measure 7 ft. over-all.

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General

The American Steel Foundries was organized in 1902 by the consolidation of several steel foundries, several of which are among the pioneers in the steel castings industry in the United States. It has nine plants located in the middle west and in the eastern states, with a total capacity of 300,000 tons annually. Eight of these plants are steel foundries, the ninth being devoted to the manufacture of springs, brake beams and clasp brake equipment.

Types of Cast Steel Pipe Fittings.

The railroads of the United States are large users of steel castings and this has resulted in the development by the American Steel Foundries of various specialties for use on cars and locomotives, among which are the Davis Steel Wheel, the Simplex Clasp Brake, the Simplex Coupler, the Economy Draft Arm, the "A. S. F." Yoke and Eclipse Yoke. The corporation is particularly well known for these products but is also a manufacturer of miscellaneous castings of all types, and of sizes ranging from 100,000 lb. battle ship steel castings to small articles weighing as low as 5 ozs. Castings for bridges and buildings, springs used in frogs and switches, boiler and pipe fittings, and cast steel gears and pinions for use in machinery of various kinds are prominent among its products for railway maintenance.

These specialties have been in extensive use on American railroads for years and are of established durability. In connection with their production the corporation maintains an organization of skilled and progressive foundrymen and adheres to the practice of placing its products on the market only after being satisfactorily developed and tested. Also the corporation is so organized that each of the several foundries devotes its attention specially to certain classes of products. Modifications and improvements, required by changing conditions of service, are made from time to time by a staff of engineers familiar with railway devices, the products of the corporation thus being maintained in conformity with the best practice. The experience of this engineering staff is always at the disposal of the railroads.

The general office of the American Steel Foundries is at Chicago, and branch offices are maintained at New York City; St. Louis, Mo.; Washington, D. C.; Cleveland, Ohio; Denver, Colo.; St. Paul, Minn.; and Philadelphia, Pittsburgh, and Chester, Pa. The nine plants of the American Steel Foundries are located at Indiana Harbor and Hammond, Ind.; Granite City, and East St. Louis, Ill.; Alliance, Ohio; and Pittsburgh, Sharon, Franklin, and Chester, Pa.

Gears and Pinions

Cast steel gears and pinions are employed in numberless ways in maintenance from the section motor car to the complete locomotive coaling plant. The accuracy with which the gears are cast, the quality of steel entering into them and the grade of workmanship employed often determine the efficiency of the various machines into which they enter. The gears and pinions made by the American Steel Foundries are of all the types required in machine design.

Boiler and Pipe Fittings

Boiler and pipe fittings, of standard or special design, are required on the railroads for use in water, steam, air or gas lines and those subjected to high pressures, as in steam and sometimes in water mains, require a superior grade of metal and the best workmanship.

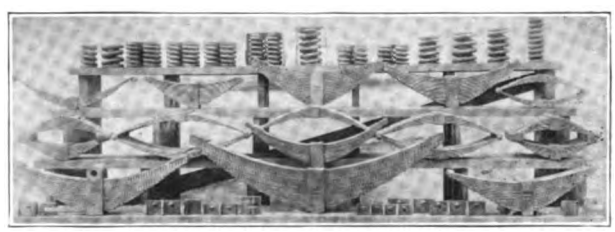
The American Steel Foundries makes all types of cast steel pipe fittings including superheater return bends, and main steam leader (dry pipe) castings. Each fitting is tested before shipment in order to insure its satisfactory performance in service.

Open Hearth Bridge Castings

Included in the general classification of railway bridge castings are various kinds of columns and their caps and bases, brackets, counterweights, footings, bridge shoes and thrust blocks, the latter being still used to a considerable extent in the building up of spans. Castings also are required frequently for the raising of existing bridge structures to effect greater clearance. The wide difference in size and construction existing among these several types of castings of necessity requires the use of different processes in their manufacture. The American Steel Foundries has had a large experience in the production of castings for this field and is prepared to make them according to specifications or to prescribe the specifications of manufacture.

Springs

The springs used in frogs and switches are subjected to repeated stresses, which necessitate a high grade of material and a high class manufacture. The American Steel Foundries has a modern plant at Hammond, Ind., for the manufacture of all types of springs for cars, locomotives or maintenance structures. Elliptic,



Types of Springs

coil and volute springs of any capacity can be furnished in accordance with the specifications and tests of the American Society for Testing Materials. These have demonstrated a dependable service under the severest conditions.

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General

The American Steel & Wire Company manufactures wire for every railway purpose. It also maintains engineering bureaus to co-operate with the railroads in the use of its wire and wire products.

Its sales offices are located at:

Chicago	208 So. La Salle Street
New York	30 Church Street
Worcester	94 Grove Street
Boston	120 Franklin Street
Cleveland	Western Reserve Building
Pittsburgh	Frick Building
Buffalo	337 Washington Street
Detroit	Foot of First Street
Philadelphia	Pennsylvania Building
Baltimore	32 So. Charles Street
Wilkesbarre, Pa.	Miners Bank Building
Cincinnati	Union Trust Building
Oklahoma City	First National Bank Building
St. Louis	Liberty Central Trust Company Building
St. Paul, Minn.	Pioneer Building
Kansas City	417 Grand Avenue
Denver	First National Bank Building
Salt Lake City	Walker Bank Building

Its export business is handled through
The United States Steel Products Company
Export Department: New York City
Pacific Coast Department: San Francisco, Portland
Seattle, Los Angeles, New Orleans

For the convenience of its customers warehouses are established at the following points:

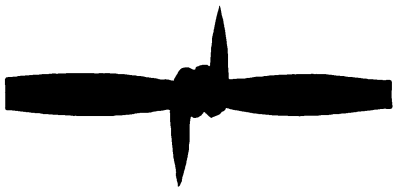
Baltimore, Md.	Los Angeles, Calif.	Richmond, Ind.
Buffalo, N. Y.	Louisville, Ky.	San Francisco, Calif.
Chicago, Ill.	New Haven, Conn.	Savannah, Ga.
Cleveland, Ohio	New Orleans, La.	Seattle, Wash.
Denver, Colo.	New York, N. Y.	St. Louis, Mo.
Des Moines, Ia.	Philadelphia, Pa.	St. Paul, Minn.
Detroit, Mich.	Pittsburgh, Pa.	Trenton, N. J.
Fargo, N. D.	Portland, Ore.	Worcester, Mass.
Kansas City, Mo.		

Plain Wire Fences

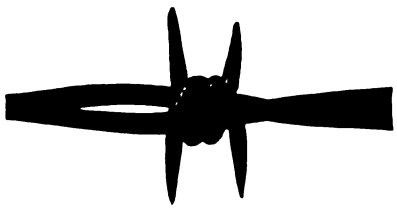
The American Steel & Wire Company manufactures plain fence wire, cable barbless wire and ribbon wire in a wide variety of patterns, gauges and finishes to suit all purposes.

Besides plain wire, a special galvanized coiled spring steel fence wire is supplied, so coiled that it will retain its springiness under all changes of temperature. American barbed wire is made in eight different types, the American Glidden Two Point and the Lyman Four Point being typical designs. These are made in thickset or hog wire, with the barbs 3 in. or 4 in. apart, and in regular or cattle wire, with the barbs 5 in. or 6 in. apart, respectively. The main strands are of No. 12 steel wire gauge and the barbs are of No. 14 steel wire gauge. The cable, or twisted barbless wire, is 2-, 3-, or 4-ply, the first being a stock pattern in No. 11, 12 and 12½ gauges. The ribbon wire is made from ½-in. No. 17 gauge wire and is extra galvanized. All plain, barbed and ribbon wire is put up on standard wood or steel reels.

American Glidden



Two Point
Lyman

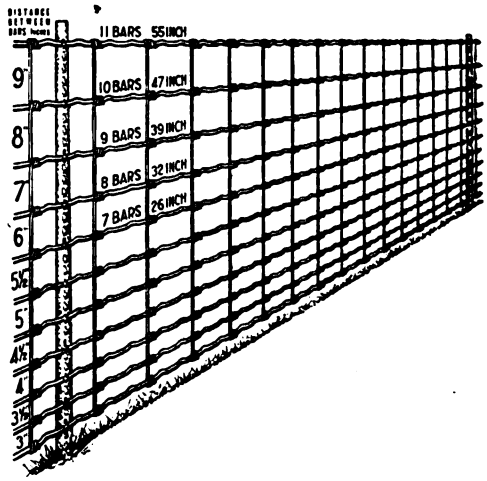


Four Point

American Railroad Fence

Woven wire fencing is made in all weights, heights and designs required in railway service. The usual height of fence is from 48 in. to 55 in., while the spacing of the line wires and the distance between the stay wires depend upon the farm animals to be excluded.

American wire fence is made throughout of the full gauge indicated. Either open hearth or Bessemer steel is used in the making of the wire, and the requisite care is taken in its manufacture to assure that the wire will be neither too hard nor too soft. It is tough and strong and yet can be spliced with ordinary tools. In galvanizing, the wire after being cleansed, is passed through a bath of molten zinc, or spelter as it is commonly called, but never more than once, as a second bath will only melt off the first coat. The coating is applied uniformly so as to avoid all bare and thin spots, and is made thick enough to prevent cracking or flaking off while splicing the wires. The hinge joint in the American fence prevents the permanent bending of the stay wirs or the crushing of the fence under pressure, while the tension curve in the wires provides ample allowance for contraction and expansion due to temperature.



American Raliroad Fence

Styles of American Railroad Fence

The American railroad fence of Regular and all No. 9 styles, is made in various heights between 26 in. and 55 in., the sizes below the intermediate one being generally used with two or three top strands of barbed wire. These

Design No.	No. of Horizontal Wires	Approx. Height in Inches	STAY WIRES 12 INCHES APART — Approximate Weight per Rod Pounds	STAY WIRES 6 INCHES APART — Approximate Weight per Rod Pounds
1155	11	55	12.2	16.7
1047	10	47	10.9	14.8
939	9	39	9.7	13.1
832	8	32	8.6	11.4
726	7	26	7.5	9.8
ALL No. 9				
1155	11	55	18.0	25.3
1047	10	47	16.0	22.3
939	9	39	14.1	19.6
832	8	32	12.3	17.0
726	7	26	10.6	14.5

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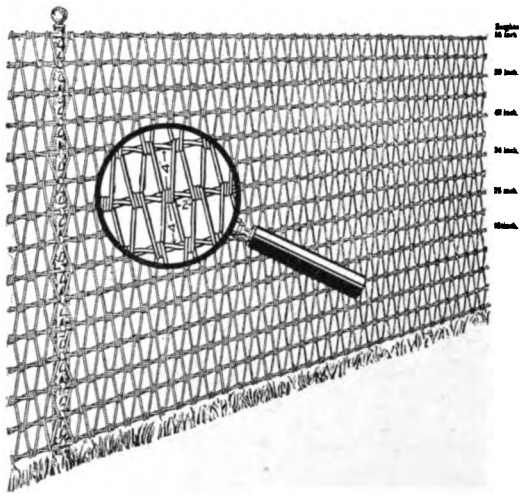
styles of fencing are put up in rolls of 24 to 40 rods each. A special design of All No. 9 fence is made in heights between 61 in. and 88 in., specially for use where a park or paddock is located along the right-of-way, and is furnished in rolls of 10 to 20 rods. The special All No. 7, which is an exceptionally strong style of fence, is made with stays 12 in. to



Ellwood Station Grounds Fence

24 in. apart and in heights similar to the typical fence. It is supplied in rolls of 20 to 30 rods.

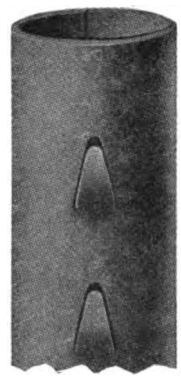
The American Steel & Wire Company makes a special type of fence adapted to station grounds and rights-of-way through cities and along parks where it is liable to receive hard usage and where it is important that trespassers be excluded. The fence

Heights shown below apply to all three styles— Spec. I, J and K		Specifications I Construction 2-Strand No. 12½ Horizontal Cables No. 14 Cross Wires	Specifications J Construction 2-Strand No. 12½ Horizontal Cables No. 12½ Cross Wires	Specifications K Construction 3-Strand No. 12½ Horizontal Cables No. 12½ Cross Wires
Approx. Weight in Inches	No. of Horizontal Cables	Approximate Weight per Rod Pounds	Approximate Weight per Rod Pounds	Approximate Weight per Rod Pounds
58	15	29.4	38.3	44.6
50	13	25.3	32.9	38.4
42	11	21.2	27.6	32.2
34	9	17.2	22.2	26.0
26	7	13.1	16.9	19.8
18	5	9.0	11.5	13.6

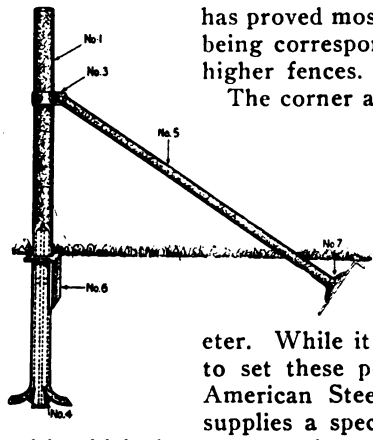
is called the Ellwood Station Ground Fence, and is made in 4-in. and 2-in. mesh. in heights from 18 in. to 58 in., the several specifications and the weights for the 2-in. mesh being given in the tables.

American Fence Posts

The American Galvanized Post dates back for more than 22 years, during which time fully 20,000,000 of them have been placed in service. By the development of new methods for making and galvanizing the posts a heavier type is now being supplied without any advance in price. The advantages of this post are: increased strength due to its increased weight; resistance to the influence of atmospheric conditions, such as fire, lightning, etc.; anchorage, which is provided by the base expanding in the soil as the post is driven down; absence of staples, which are replaced by the tongues on the post; no heaving from frost, so that driving the posts from 24 in. to 30 in. in the ground is sufficient; saving in land through the small size of the post; improved appearance due to the uniform size, length and neatness of the fence. The lasting qualities of the American post are insured by the thick coat of zinc which is applied after the post is formed. This coating is made extra heavy below the ground line, and a heavy protection is provided both inside and out.



In form the line posts are cylindrical and of 1¾ in. diameter. They carry a series of tongues, spaced 1½ in. apart for attaching the wire fencing. They are made of the best steel sheets in lengths of 5, 6½, 7, 7½, 8, 9, 10 and 11 ft. and in No. 14½ gauge metal. For general purposes, where the fence is not more than 48 or 50 in. high, the 6½-ft. post has proved most effective, the length being correspondingly increased for higher fences.



The corner and end post similarly are made of the best steel sheets, in lengths of 7, 7½, 8, 9, 10 and 11 ft., and of No. 10 gauge metal. These posts also are cylindrical but of 3-in. diameter. While it is the usual practice to set these posts in concrete, the American Steel & Wire Company supplies a special post and fixtures with which the posts may be set in the ground without concrete. The fittings for the end post are a spreader, brace collar, brace plate and face plate, while those for the corner post have all but the first and last items in duplicate.

For use with the American galvanized steel fence posts extension arms are made which carry four lines of barbed wire. These arms are neat, strong and easily attached, no staples being required. They are shipped detached and are fastened to the posts by two bolts thoroughly coated with zinc.

American Gates

The American tubular steel gates are made of new National tubing of large diameter and having no open seams. The frames in the drive gates are further reinforced by large diagonal brace which keeps the gate firm and prevents sagging. The frames are furnished galvanized or painted as desired. The galvanized frames are heavily coated and will withstand corrosion better than the painted ones.

Width of Opening	Heigh of Gate	Approx Weight Pounds
8 ft.	42 in.	53
8 ft.	50 in.	57
8 ft.	58 in.	63
10 ft.	42 in.	56
10 ft.	50 in.	61
10 ft.	58 in.	67
12 ft.	42 in.	65
12 ft.	50 in.	71
12 ft.	58 in.	77
14 ft.	42 in.	73
14 ft.	50 in.	80
14 ft.	58 in.	87
16 ft.	50 in.	106
16 ft.	58 in.	115

The fabric in the American single drive gate is a 2-in. diamond mesh of truss form in which the lateral wires are of No. 10 gauge and the diagonal wires of No. 12½ gauge. This proves a barrier to small

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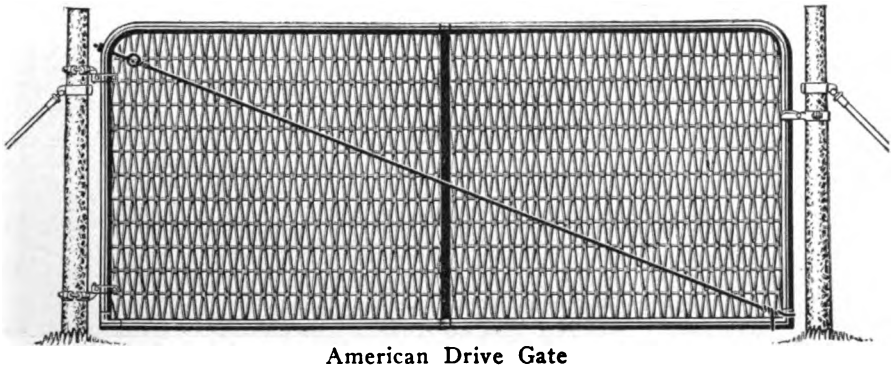
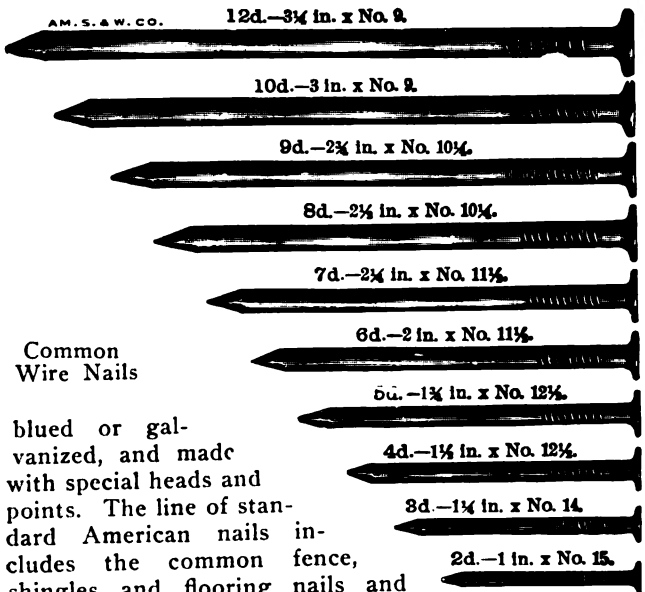
animals, adds to the strength of the gate and makes it practically unclimable, since it does not offer a foothold. The drive gate is made 10, 12, 14 and 16 in. wide, and 42, 50 and 58 in. high. The walk gate is similar in design to the drive gate and is made in the same heights, but of 3 and 4-ft. widths.



American Drive Gate

American Wire Nails

The American Steel & Wire Company makes nails in a wide range of styles and sizes, adapting them to all requirements, and in addition makes special kinds to suit specifications. Careful attention is devoted to the selection of the proper grade of stock, and equal care is used to secure heads of the proper size and the right kind of points, and above all, a uniformity of length and gage for each kind and size. The nails are thoroughly cleansed and polished before packing and are given a rigid inspection. Also furnished annealed, blued or galvanized, and made with special heads and points. The line of standard American nails includes the common fence, shingles and flooring nails and brads; barbed common and car nails; siding, box, finishing, slating and roofing nails; clinch, hinge and boat nails, and spikes; and barbed dowel pins. The illustration shows the various sizes of common nails up to 12d.

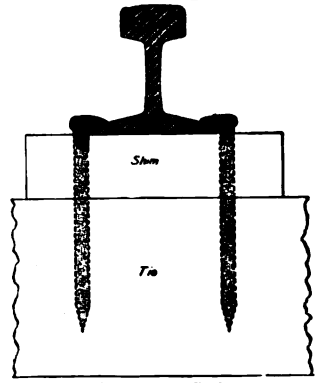


Common Wire Nails

American round wire spikes are made only in flat head, diamond point or in oval head, chisel point, and in lengths from 3 in. to 14 in. The American Steel & Wire Company also makes boat spikes and railroad spikes. The boat spikes are made in the square pattern with chisel points and in sizes from ¼ in. to ⅝ in. square and from 3 in. to 14 in. long.

American Boat Spike

Shimming spikes also are furnished for fastening the rails where the spike is to be driven through the shim and well into the tie. Shimming spikes are usually called for in 7, 8 and 9-in. lengths and of 9/16-in. and ⅝-in. column.

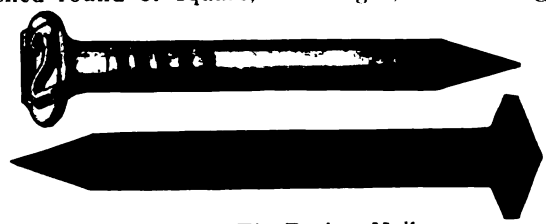


Shimming Spikes

Fence Staples

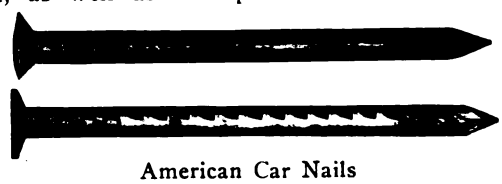
American fence staples are furnished polished or galvanized, the latter being preferable for woven wire fence when used on wood posts. Fence staples are packed in kegs containing 100 lb. or in 5, 10, 15, 25 and 50 lb. boxes. They are made usually of No. 9 wire.

The dating nails, used for marking ties, are furnished round or square, and bright, tinned or galvanized. They are made according to the specifications of the railroad.



American Tie Dating Nails

Car nails are used in manufacturing new equipment, as well as in repair work. American car nails are made in all standard lengths, both light and heavy, oval and flat head, bright and annealed. the former finish being usually preferred.



American Car Nails

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American Wire Rope and Fittings

American wire rope is manufactured in five grades: iron rope, crucible cast steel rope, extra strong crucible cast steel rope, plow steel rope and monitor plow steel rope. The grade which ordinarily is adequate for the requirements of maintenance-of-way service is the crucible cast steel rope. It is hard and resists well external wear such as that encountered in dragging over rocks when used with the unloading plow. The steel from which this grade is made has a tensile strength when drawn into wire and properly treated of 180,000 to 240,000 lb. per sq. in. of sectional area. The several higher grades of rope have each a tensile strength about 12½ per cent greater than the next lower grade and are, of course, preferable when heavier duty is required. The particular advantages of the higher grades are also emphasized when the capacity of the machinery has to be increased without increase in the size of the sheaves or drum.

The American Steel & Wire Company transmission, haulage or standing rope is composed of 6 strands of 7 wires each, laid around a hemp core. It can be supplied in all the five qualities and is adapted to places where the wear is excessive, its coarse wires resisting abrasion and corrosion to the greatest possible extent. The company also makes a line of hoisting rope consisting of 6 or 8 strands of cable made with 19, 37 or 61 wires and laid around a hemp core. The grades regularly manufactured are the standard hoisting rope with 6 strands of 19-wire cable; the extra flexible hoisting rope, with 8 strands in place of 6, which supplies its increased flexibility; the extra special flexible hoisting rope, with 6 strands of 37-wire cable, wherein more than 50 per cent of the strength is in the inner wires which are not subject to wear; and the extra special flexible hoisting rope with 6 strands of 61 wire cable, laid around a special wire center, which is a specially useful rope for dredging purposes.

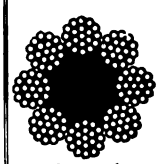
The special ropes manufactured by the company are: A non-spinning hoisting rope, required with single line derricks; a flattened strand hoisting rope, in a type of construction which supplies 150 per cent increased wearing service; and the steel-clad hoisting rope in which each strand is encased in flat strips of steel wound spirally about them, affording additional resistance to wear without sacrificing flexibility.

American galvanized steel strand, adapted to the guying of poles, smokestacks, etc., is composed of 7 or 19 steel wires twisted into a single strand, and is either galvanized or extra galvanized. American sash cord is made up of 6 strands, 7 wires to the strand, with 1 cottom core. It is furnished "dead soft," unless ordered otherwise, and may be furnished galvanized. The data for the wire strand and the sash cord are contained in the tables.

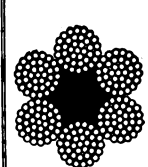
The American Steel & Wire Company supplies wire rope fittings of every kind. Its oval thimbles

DATA ON VARIOUS TYPES OF HOISTING ROPES

Diameter in Inches	Approximate Weight per Foot in Pounds	Monitor Plow Steel: Approximate Strength in Tons of 2000 Pounds	Monitor Plow Steel: Proper Working Load in Tons of 2000 Pounds	Plow Steel Crucible Cast Steel: Approximate Strength in Tons of 2000 Pounds	Plow Steel Crucible Cast Steel: Proper Working Load in Tons of 2000 Pounds	Extra Strong: Approximate Strength in Tons of 2000 Pounds	Extra Strong: Proper Working Load in Tons of 2000 Pounds	Crucible Cast Steel: Proper Working Load in Tons of 2000 Pounds	Crucible Cast Steel: Approximate Weight per Foot in Pounds	Iron: Approximate Strength in Tons of 2000 Pounds	Iron: Proper Working Load in Tons of 2000 Pounds
STANDARD HOISTING ROPE—6 STRANDS, 19 WIRES TO THE STRAND, 1 HEMP CORE											
2¾	11.95	315	63	275	55	243	48.6	211	42.2	111	22.2
2½	9.85	263	53	229	46	200	40	170	34	92	18.4
2¼	8	210	42	186	37	160	32	133	26.6	72	14.4
2	6.30	166	33	140	28	123	24.6	106	21.2	55	11
1⅞	5.55	150	30	127	25	112	22.4	96	19	50	10
1¾	4.85	133	27	112	22	99	19.8	85	17	44	8.8
1⅝	4.15	110	22	94	19	83	16.6	72	14.4	38	7.6
1½	3.55	98	20	82	16	73	14.6	64	12.8	33	6.6
1⅜	3	84	17	72	14	64	12.8	56	11.2	28	5.6
1¼	2.45	69	14	58	12	53	10.5	47	9.4	22.6	4.56
1⅛	2	56	11	47	9.4	43	8.6	38	7.6	18.6	3.72
1	1.5	45	9	38	7.6	34	6.80	30	6	14.5	2.90
⅞	1.20	35	7	29	5.8	26	5.20	23	4.6	17.8	2.36
¾	.89	26.3	5.3	23	4.6	20.2	4.04	17.5	3.5	8.5	1.70
⅝	.62	19	3.8	15.5	3.1	14	2.80	17.5	2.5	6	1.20
⅝	.50	14.5	2.9	12.3	2.4	11.2	2.24	10	2	4.7	.94
½	.39	12.1	2.4	10	2	9.2	1.84	8.4	1.68	3.9	.78
⅞	.30	9.4	1.9	8	1.6	7.25	1.45	6.5	1.30	2.9	.58
⅜	.22	6.75	1.35	5.75	1.15	5.30	1.06	4.8	.96	2.4	.48
⅝	.15	4.50	.9	3.8	.76	3 50	.70	3.1	.62	1.5	.30
¼	.10	3.15	.63	2.65	.53	2.43	.49	2.2	.44	1.1	.22
EXTRA FLEXIBLE HOISTING ROPE—8 STRANDS, 19 WIRES TO THE STRAND, 1 HEMP CORE											
1½	3.19	80	16	74	14.8	66	13	58	11.6		
1⅜	2.70	68	13	64	12.8	57	11	51	10.2		
1¼	2.20	56	11	52	10.4	47	9.4	42	8.4		
1⅛	1.80	46	9.2	43	8.6	38	7.6	34	16.8		
1	1.42	36	7.2	33	6.6	29.7	5.9	26	5.2		
⅞	1.08	28	5.6	26	5.2	23	4.6	20	4		
¾	.80	22	4.4	20	4.4	17.6	3.5	15.3	3.06		
⅝	.56	15	3	14	2.8	12.4	2.5	10.9	2.18		
⅝	.45	12	2.4	11.6	2.32	10.1	2	8.7	1.74		
½	.35	9.5	1.9	8.7	1.74	8	1.6	7.3	1.46		
⅞				6.90	1.38	6.30	1.26	5.7	1.14		
¾				5.12	1.02	4.66	.93	4.2	.84		
⅝				3.35	.67	3.05	.61	2.75	.55		
¼				2.25	.45	2.02	.40	1.80	.36		
EXTRA SPECIAL FLEXIBLE HOISTING ROPE—6 STRANDS, 61 WIRES TO THE STRAND, 1 HEMP CORE											
2¾	11.95	278	55	265	53	233	47	200	40		
2½	9.85	225	45	214	43	187	37	160	32		
2¼	8	184	37	175	35	150	30	125	25		
2	6.30	137	27	130	26	117	23	105	21		
1⅞	5.55	125	25	119	23.8	106	21.2	94	18.8		
1¾	4.85	113	23	108	22	95	19	84	17		
1⅝	4.15	95	19	90	18	79	16	71	14		
1½	3.55	84	17	80	16	71	14	63	12		
1⅜	3	71	14	68	14	61	12	55	11		
1¼	2.45	58	11	55	11	50	10	45	9		
1⅛	2	46	9.2	44	9	39	8	34	7		
1	1.58	37	7.4	35	7	32	6.4	29	6		
⅞	1.20	29	5.8	27	5	25	5	23	5		
¾	.89	23	4.6	21	4	19	3.8	17.5	3.5		
⅝	.62	16	3.2	14	3	12.6	2.5	11.2	2.2		
⅝	.50	12.5	2.5	11.5	2.3	10.5	2.1	9.5	1.9		
½	.39	9.75	1.9	9.25	1.85	8.25	1.65	7.25	1.45		
⅞	30	7.50	1.5	7.2	1.4	6.35	1.27	5.5	1.1		
⅜	.22	5.30	1.06	5.1	1	4.65	.93	4.2	.84		
SPECIAL FLEXIBLE HOISTING ROPE—6 STRANDS, 37 WIRES TO THE STRAND, 1 HEMP CORE											
3¼	16.60	370	74	350	70	315	63	280	56		
3	14.20	325	65	310	62	275	55	240	48		
2¾	11.95	278	56	265	53	233	47	200	40		
2½	9.85	225	45	214	43	187	37	160	32		
2¼	8.00	184	37	175	35	150	30	125	25		
2	6.30	137	27	130	26	117	23	105	21		



8 Strands
19 Wires



6 Strands
37 Wires

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used for splicing into rope are heavily coated with zinc. The A. S. & W. wire rope clips are useful for supporting tipple screens, loading booms and similar structures. The iron guy shackles are much employed as neck ropes, the ends of which are clipped with thimbles, sockets, turnbuckles, etc. The closed sockets when properly attached, form the strongest rope fastening made, developing in fact the entire strength of the rope. They are made drop forged and, being weldless, will outlast the rope. The open sockets permit the insertion of a closed link. The socket and chain also has occasional uses. Turn-buckles, sheaves, snatch blocks, hooks and slings are furnished suitable for use with wire rope of all sizes and grades.

DATA ON GALVANIZED WIRE STRAND

Diameter Inches	Size of Wire Used Steel Wire Gauge	Approximate Weight per 1000 Feet in Pounds	Approximate Strength in Pounds
7 Wires Twisted Into a Single Strand			
¾	3	1,200	16,700
13/16	5	813	11,600
11/16	6	671	9,600
½	8	517	7,400
7/16	9	399	5,700
¾	11	296	4,250
5/16	12	205	3,200
9/32	13	164	2,570
¼	14	121	1,900
7/32	15	98.3	1,540
5/32	16	72.9	1,150
9/64	17	51.3	870
1/8	18	40	700
7/64	19	31.8	540
1/16	20	25	450
5/128	21	20	400
1/64	22	13	300
19 Wires Twisted Into a Single Strand			
1	.200	2,073	28,700
7/8	.175	1,581	21,900
¾	.150	1,155	16,000
5/8	.125	796	11,000
9/16	.110	637	9,640
½	.100	504	7,620

DATA ON SASH CORD

Diameter in Inches	Weight per Foot in Pounds		Approximate Breaking Stress in Pounds		
	Iron	Copper	Bright Iron	Annealed Iron	Bright Copper
¼	.101	.115	2200	1650	1320
7/32	.077	.087	1800	1411	1080
5/16	.056	.064	1400	1100	840
⅛	.025	.029	550	425	350
9/64	.014	.016	320	250	200
1/16	.006	.007	140	110	90

American Electrical Wires

The American Steel & Wire Company makes bare copper wires and cables for telegraph, telephone and power transmission purposes; insulated wires of all kinds, such as weatherproof wires and cables, magnet, annunciator and office wire; lamp cord, submarine cables, car wires, together with all kinds of rubber covered wires and lead encased cables for interior and exterior purposes.

The hard drawn copper telegraph and telephone wire is in the gauges and of the approximate weight per mile given in the table. Tinned copper wires and cables are made in all constructions, solid, stranded or flexible. The bare copper cables are made in both concentric and rope laid strands, while hemp core cables are made to any special specifications. A special transmission strand is made which consists of a combination of high strength steel wire and hard drawn copper wire twisted into a concentric strand of 7, 19, 37, or more wires, with the copper wires on the inside. This strand has high tensile strength such as that required when transmission lines are stretched over long spans.

American rail bonds are made of any desired type, capacity and length. The five styles regularly manufactured are: crown rail bonds, with rounds conductors; United State rail bonds with flat wire conductors; twin terminal bonds to be attached to the heads of the rails; soldered rail bonds; and arc weld rail bonds. Only pure soft copper of high conductivity is used in any portion of these bonds.

American extra galvanized W. & M. telephone and telegraph wire is made in three grades: Extra Best Best, (E.B.B.), which is made by an improved continuous process rendering it uniform in quality, pure, tough and pliable; Best Best, (B.B.), which is superior to E.B.B. in mechanical qualities and equal in galvanizing, but of somewhat lower electrical value; and steel (or homogeneous metal), which is designed for short line service where a measure of conductivity can be exchanged for high tensile strength in a light wire. All these grades are galvanized to the highest commercial standard, and each grade is marked with a metal seal attached to the coil.

Number, Birmingham Wire Gauge	Diameter in Inches	Weight in pounds per 1,000 feet	Weight in pounds per mile	In Bundles (miles)	Approximate breaking strain (pounds)			Average resistence per mile at 68° F (International ohms)		
					E. B. B.	B. B.	Steel	E. B. B.	B. B.	Steel
4	.238	153	811	¼	2,028	2,271	2,433	5 98	7.15	8.32
6	.203	112	590	⅓	1,475	1,652	1,770	8.22	9.83	11.44
8	.165	74	390	½	975	1,092	1,170	12.43	14.87	17.31
9	.148	60	314	½	785	897	942	15.44	18.47	21.50
10	.134	49	258	½	645	722	774	18.79	22.48	26.16
11	.120	39	206	½	515	577	618	23.54	28.16	32.77
12	.109	32	170	½	425	476	510	28.52	34.12	39.71
14	.083	19	99	½	247	277	297	48.98	58.59	68.18

The galvanized bond wire, used for signal bonding on steam operated roads, is nearly always of E.B.B. extra galvanized wire, usually in lengths from 3 ft. to 5 ft., and made of any desired gauge. The wires in 13-in. lengths are used for fastening telegraph and telephone wires to the insulators.

Other wires and cables supplied by the American Steel & Wire Company are the Americore rubber covered wire in the insulated and stranded form; the double and triple grade of "Reliance" wire for outdoor service; and a slow burning wire for interior use. Solid conductor lead encased wire cables are made in all varieties. Amerite rubber covered and signal wires and cables are furnished in any size and finish and for all voltages. American lamp cord and reinforced portable cords are made so as to pass the inspection of the Underwriters' laboratories.

American Wire Gauge (B. & S.)

Number	Diameter in Decimal of an Inch	Approximate Weight per Mile in Pounds
8	.1285	264
9	.1144	209
10	.1019	166
12	.0808	104
14	.0641	66
British, Imperial, or English Legal Standard Gauge		
8	.160	409
9	.144	331
10	.128	262
12	.104	173
14	.080	102

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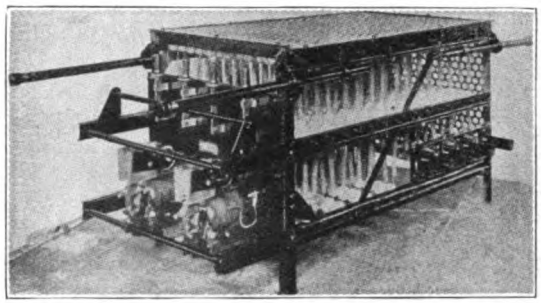
Arc Weld Rail Bonds

In the manufacture of the arc weld rail bond copper filling material is melted in by means of a carbon electrode, being thereby fused with a steel plate ⅛ in. thick and with a strand and sleeve , thus forming a copper terminal faced with steel. The steel face is necessary in order that the bond may be welded to the rail in the field by means of the metallic electrode process of arc welding.

The equipment for this process is known as the A. S. & W. Rail Bonding and Arc Welding Machine and consists of spirally wound resistance wire, assembled in a light, durable, ventilated metal frame, and thoroughly insulated from the frame. The unit is designed to operate directly from high tension lines



and it can be used wherever the power lost in the rheostat is not objectionable. The unit is light in weight and is equipped with handles, making it easily portable. Exposure to the weather will not injure the insulation or the resistance wire. Taps are provided so that a range of welding current can be obtained from 60 to 200 amperes with intermediate stops of 15 amperes each.

By the resistance method the 550-volt or 250-volt current may be used directly for welding without transformation. The resistance is provided with taps so that the current may be varied to suit the welding operation. The advantages of the method are: (1) light weight; (2) lower first cost and maintenance; and (3) simplicity. Bonding has been done by the resistance method with good success and a joint is made which is both mechanically and electrically permanent.

Triangle Mesh Reinforcements

Triangle Mesh Steel Woven Wire Reinforcement is made with either single or stranded longitudinal tension members. The single wire member is made in different sizes from No. 12 to No. 2 gauge. The stranded longitudinal is composed of two or three wires varying from No. 6 to No. 3½ gauge, and stranded or twisted together with a long lay. The longitudinals, whether single or stranded, are spaced 4-in. centers. The transverse or diagonal cross wires are woven between the longitudinals so that perfect triangles are formed thereby, not only lending additional carrying strength to the tension members, but furnishing uniform distribution of the steel. A hinge joint is provided on each longitudinal, which enables the reinforcement to be folded longitudinally in any desired shape, adapting it to all kinds of concrete construction.

The design provides a perfect mechanical bond between the steel and the concrete, and the steel, not being galvanized unless specially desired, develops the maximum adhesive bond. A sufficient area of steel is provided in the cross wires of the triangle mesh reinforcement to prevent temperature cracks, thereby removing the need for laying additional reinforcement at right angles to the longitudinal or tension members. Where additional strength above that of the heaviest of the triangle mesh is necessary it may be obtained by the use of a number of loose bars along with the mesh reinforcement.

Triangle mesh reinforcement is made in 150-ft. lengths, and of eleven widths, increasing by increments of 4 in., from 16 in to 56 in., the details of the reinforcement being shown in the tables. Stocks are carried at the mills and at various warehouses.

Number of Gauge of Wires, Areas per Foot Width and Weights per 100 Square Feet

Longitudinals Spaced 4 Inches. Cross Wires Number 14 Gauge Spaced 4 Inches

Style Number	Number and Gauge of Wires each Longitudinal American Steel & Wire Company's Steel Wire Gauge	Total Effective Longitudinal Sectional Area Square Inches Per Ft. Width	Approximate Weight, lbs., Per 100 Square Feet
032	1—No. 12 gauge	.032	22
040	1— " 11 "	.040	25
049	1— " 10 "	.049	28
058	1— " 9 "	.058	32
068	1— " 8 "	.068	35
080	1— " 7 "	.080	40
093	1— " 6 "	.093	45
107	1— " 5 "	.107	50
126	1— " 4 "	.126	57
146	1— " 3 "	.146	65
153	1— ¼ inch	.153	68
168	1—No. 2 gauge	.168	74
180	2— " 6 "	.180	78
208	2— " 5 "	.208	89
245	2— " 4 "	.245	103
267	3— " 6 "	.267	111
287	3— " 5½ "	.287	119
309	3— " 5 "	.309	128
336	3— " 4½ "	.336	138
365	3— " 4 "	.365	149
395	3— " 3½ "	.395	160

Longitudinals Spaced 4 Inches. Cross Wires Number 14 Gauge Spaced 8 Inches

036P	1—No. 12 gauge	.036	17
044P	1— " 11 "	.044	20
053P	1— " 10 "	.053	24
062P	1— " 9 "	.062	27
072P	1— " 8 "	.072	31
084P	1— " 7 "	.084	35
097P	1— " 6 "	.097	40

Longitudinals Spaced 4 Inches. Cross Wires Number 12½ Gauge Spaced 8 Inches

041R	1—No. 12 gauge	.041	21
049R	1— " 11 "	.049	24
058R	1— " 10 "	.058	28
067R	1— " 9 "	.067	31
077R	1— " 8 "	.077	35
089R	1— " 7 "	.089	40
102R	1— " 6 "	.102	44

Longitudinals Spaced 4 Inches. Cross Wires Number 14 and Number 12½ Gauge Spaced 2 Inches
(This material is used principally for cement gum work.)

Style Number	Number of Wires Ea. Long	Long Gauge of Wire Each	Gauge of Cross Wires	Approximate Weight per 100 Square Feet
7-A	1	12	14	31
6-A	1	10	14	37
5-A	1	8	14	44
4-A	1	6	14	53
29-A	1	12	12½	42
28-A	1	10	12½	48
27-A	1	8	12½	55
26-A	1	6	12½	64

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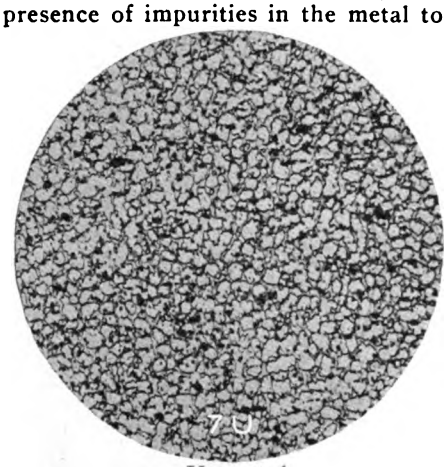
BORONIC TREATMENT OF METALS

General

The American Boron Products Company, Inc., Reading, Pa., has been engaged in the development and marketing of Boronic products for upward of five years. Stated briefly, Boronics are commercial metals of all kinds, aluminum, copper, nickel, silver, etc., charged with Boronic gases. When introduced into metal in the melted state, they serve to deoxidize, densify, toughen and purify the metal, enabling the production of solid, homogeneous casts free from blow-holes or other defects that would be likely to result from the presence of impurities in the metal to be cast.

What Boronics Do

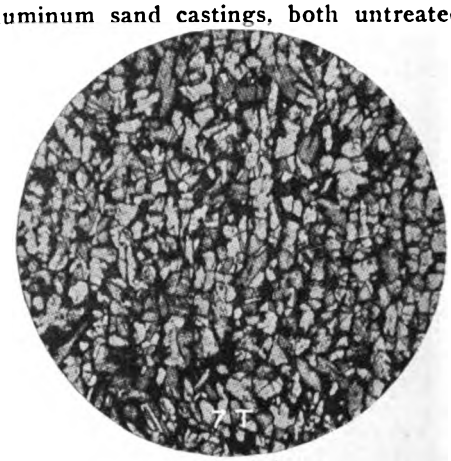
The changes in the texture of metals produced by the use of Boronics are indicated in the accompanying illustrations showing Monel metal castings, nickel bronze castings, yellow brass and aluminum sand castings, both untreated and treated with the proper Boronic product. The legend accompanying each pair of illustrations indicates the extent of the increase in tensile strength and elongation in each kind of metal.



Untreated

Yellow Brass

Micro-photographic reproductions of yellow brass before and after treatment with Boronics. This treatment increased tensile strength from 31,450 lbs. to 47,600 lbs. per square inch, and elongation from 22.7% to 28.5% in 2 inches.



Treated

The company is now marketing 27 distinct numbers of Boronics for use in every variety of metal and has met with such success in the development of the industry that preparations are being made for a great enlargement of its facilities for production.

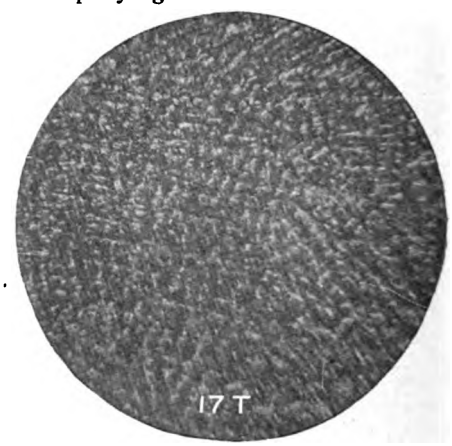
The domestic market for these products is supplied by the American Boron Products Company, Inc., the sole manufacturer, while the foreign distribution is in the hands of Edward LeBas & Co., London, E. C. 3, England; National Alloys, Limited, London, England; China & Japan Trading Co., Ltd., Kobe, Japan; China & Japan Trading Co., Shanghai, China.

The variety of Boronic products which the manufacturer is prepared to supply, and the special purposes each is particularly adapted to serve, are indicated in the accompanying list:

Untreated

Monel Metal Castings

Micro-photographic reproductions of monel metal castings, before and after treatment with Boronics. This treatment increased tensile strength from 68,400 lbs. to 83,600 lbs. per square inch, and elongation from 43.8% to 51.5% in 2 inches.



Treated

What Boronics Are

The development of the boronic products industry has been based upon the knowledge that there are few foundries that are turning out products of the highest quality where more or less difficulty in securing perfect castings is not encountered. Such difficulties, even when they are recognized, are frequently attributed to other causes than the metal itself, and for this reason are not remedied. Very few cases have been found in which the proper Boronic treatment will not only remove the difficulties but will produce a higher grade of castings than otherwise obtainable.

1. Boronic Aluminum — For deoxidizing and strengthening pure aluminum, Monel metal, iron and steel and generally improving machining qualities.
2. Boronic Copper—For deoxidizing bronzes, gold and silver.
3. Boronic Copper Alloy — Used in non-ferrous metals for deoxidizing, purifying and toughening, densifying, strenghtening and solid-casting aluminum, brasses, bronzes and babbitts. For toughening nickel-silver. For entering large percentages of lead in brasses and bronzes.

3B Boronic Copper Alloy "B"—For improving all grades of babbitts by the addition of Boronic Copper through the ordinary iron ladle process.

AMERICAN BORON PRODUCTS CO. INC., READING, PA.

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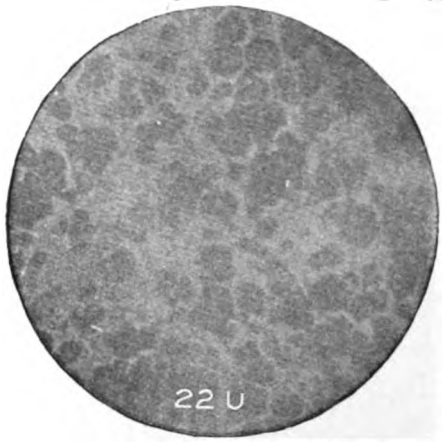
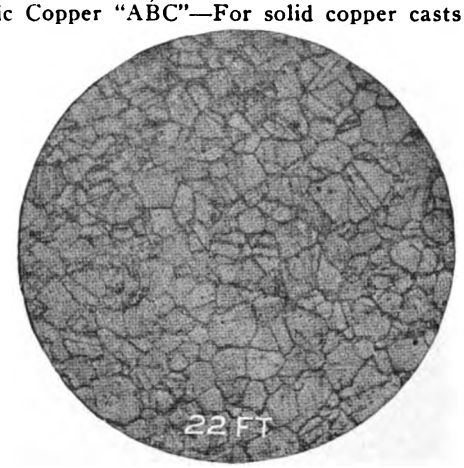
4. Boronic Copper "F3½"—For coin bronzes and mint uses in general.
5. Boronic Copper "S"—A general substitute for silicon copper and for bronzes of the silicon variety.
6. Boronic Phosphor Copper—A general substitute for phosphor copper.
7. Boronic Copper Aluminum—For iron and steel; also for producing superior forging brass in connection with No. 9, two ounces of No. 7 and four ounces No. 1, (6 oz. in all), used to 100 lb. of brass.
8. Boronic Copper Nickel (50-50)—For use in all non-ferrous compositions containing copper and nickel.



Untreated

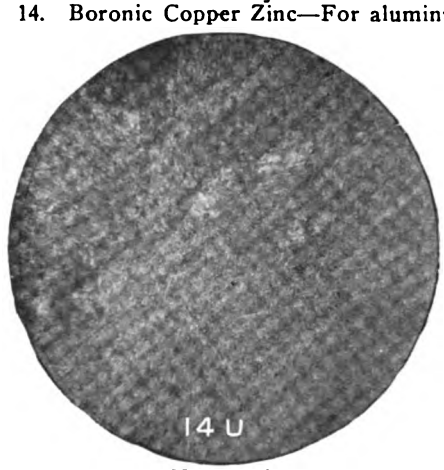
Nickel Bronze Castings

Micro-photographic reproductions of nickel bronze castings, before and after treatment with Boronics. This treatment increased tensile strength from 55,000 lbs. to 85,800 lbs. per square inch, and elongation from 19.7% to 23% in 2 inches.



Treated

For introducing nickel into brasses and bronzes and cupra nickel.
9. Boronic Copper "L"—For uniting large percentages of copper and lead, up to 50 per cent each.
10. Boronic Plastic Nickel—For producing acid-resisting metals of high nickel, such as valves, bearings, bushings of good anti-frictional qualities, resisting sulphuric acid.
11. Boronic Anti-Acid Alloy—A base alloy of nickel, manganese, copper and lead for higher anti-acid and anti-frictional products.
12. Boronic Nickel — Commercial nickel treated boronically and for use where nickel only is required.
13. Boronic Copper "PM" — Used in manganese bronzes and all red and yellow brasses.
14. Boronic Copper Zinc—For aluminum castings in



Untreated

Aluminum Sand Castings

Micro-photographic reproductions of aluminum sand castings before and after treatment with Boronics. This treatment increased tensile strength from 16,260 lbs. to 26,600 lbs. per square inch, and elongation from 3.6% to 6.2% in 2 inches.

Treated

sand or chill molds, giving great density and strength.
15. Boronic Copper "MB" — Produces a modified manganese bronze when entered in ordinary yellow brass, giving strength, density and ductility.
16. Boronic Copper "HR" — For toughening and strengthening brass and for producing aluminum forgings and auto pistons.
17. Ferro-Boronic—Copper, iron and nickel boronized and used to introduce small percentages of iron and nickel into brasses, manganese or other bronzes.
18. Boronic Copper "Fan"—For chill casts of aluminum, or for forging aluminum.
19. Boronic Nickel Alloy—An alloy of nickel and manganese to use in nickel alloy steels as a powerful deoxidizer and degasifier.
20. Boronic Zinc—To take the place of aluminum in brass, causing metal to flow freely, leaving castings without the white aluminum coating.
21. Boronic Copper "D"—For pure copper casts (sand or chill) giving highest conductivity, 2 to 4 oz. per 100 lb. of cast, being all that is required.
22. Boronic Copper "NS"—For deoxidizing nickel alloy casts of all kinds, whether in sand or chill molds (2 to 4 oz. to 100 lb. melts).
23. Boronic Copper "ABC"—For solid copper casts (sand or chill molds) of highest conductivity, where the copper contains high sulphur.
24. Boronic Silver—Fine silver treated Boronically and used for producing the highest grade silver products by the admixture of small percentages in all silver high-quality goods.

The possibilities of perfect cast steel and iron in place of the more expensive machined or forged and machined parts of machines or devices will appeal to both manufacturers and consumers of railway supplies. The brass and Monel metal valve situation is of prime importance to the entire maintenance, signal and mechanical departments of the railways. Even cast silver parts of signal devices, Boronic treated, are an engineering possibility, as silver has a greater electrical conductivity than copper.

The reduced size of crystals of the different metals due to Boronic treatment is productive of a greater resistance to fatigue. Resistance to fatigue of metals is a large factor in all branches of railway engineering. Continuous vibratory stresses produce fatigue of metals. Dense metal structure produces resistance to abrasion and adds greatly to the tensile and transverse strengths of the metal.

AMERICAN BORON PRODUCTS CO. INC., READING, PA.

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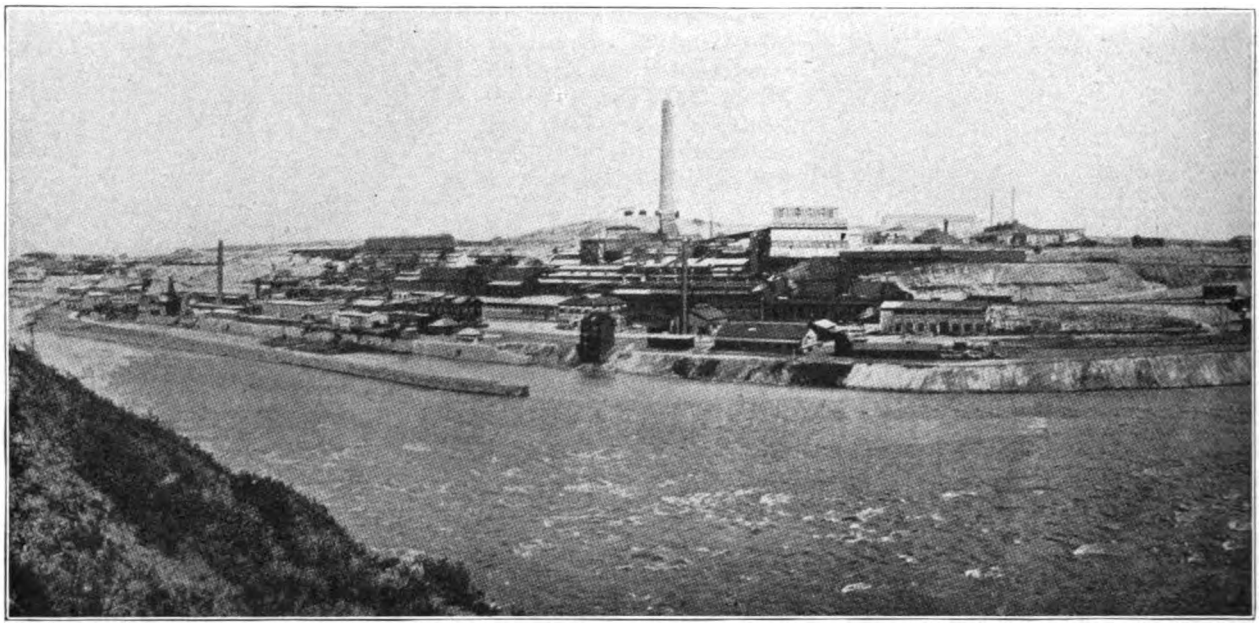
ELECTROLYTICALLY REFINED COPPER

Products

The products of the Anaconda Copper Mining Company, Rolling Mills Department, are bare copper wires and cables, for telephone, telegraph, signal, power transmission, electric railway and all industrial uses; also hot rolled copper rods in diameters from ¼ in. to 1¼ in.

Historical Data

The year 1880, which marked the beginning of Montana's important copper development, saw also the commencement of a great progress in electrical engineering with its need for large supplies of copper. For nearly forty years the Anaconda Copper Mining Company has been the chief producer in the Butte district, which has yielded annually more copper than any other single district in the world.



The Great Falls Plant of the Anaconda Copper Mining Co.

The two principal copper minerals found in the Butte district are chalcocite or glance, a sulphide of copper, and enargite, copper-arsenic-sulphide. These are shipped to the company's reduction works at Anaconda over the company's own railroad the Butte, Anaconda and Pacific.

Mining, Smelting and Electrolytic Refining

The first step in the smelting process is the mechanical concentration of the ore, which is enriched by this process from its original 3 to 8 per cent copper content. This concentration is accomplished by passing the ore through a series of crushers and rolls which break it up into fine particles, the useless part of the ore being then separated from the valuable part by the differences in their specific gravities. The concentrate, which contains sulphur and many other impurities, is then placed in a roasting furnace where a part of the sulphur is burned out. Silica, alumina and lime are now added to the charge, which is placed in a reverberatory furnace and raised to the point of fusion by the use of a fuel in conjunction with the remaining sulphur. This process produces matte with an assay of about 40 per cent copper, and slag which is run off. The matte in a molten state is poured into a converter where air under pressure is blown through the liquid mass burning out some of the impurities. These impurities form a slag which is run off by tilting the converter. The metallic copper is now run into a refining furnace where air is again blown through the liquid copper removing the remaining sulphur and iron. The use of air oxidizes the copper, and it is returned to a metallic state by the reducing action obtained by inserting poles of green wood into the molten liquid. The copper is now tapped from the furnace and cast into the form of anodes. Although this copper is 99.25 per cent pure it has to be electrolytically refined before it can be used commercially.

Some of the company's copper, which is ultimately to be made into wire, is shipped in the form of anodes to the Great Falls plant where it is electrolytically refined. The electrolytic process consists of placing the copper anode in a tank containing an electrolyte of the proper composition, and running a direct current through it to the cathode. This current dissolves the copper from the anode and deposits it in equivalent quantity on the cathodes, gold and silver and impurities being deposited on the bottom of the tank in the form of slimes. The last step in the refining process is the casting of the pure cathode copper into the required shapes. This is much more difficult than it would appear, for copper when molten absorbs gases, particularly sulphur, to such an extent that the process becomes one of refining from the gases absorbed during the melting of the copper. The cathodes are placed in a large reverberatory furnace and melted into a fluid state. Air is then blown through the charge and the resulting slag is skimmed off. The oxidized charge is now covered with charcoal, and the oxygen is reduced by poling the molten metal with green poles. The copper is now cast into wire bars, slabs, wedge bars, cakes, ingots, and ingot bars.

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From Ore to Finished Product

In 1918 the mills of the Anaconda Copper Mining Company at Great Falls, Montana, were completed for the manufacture of hot rolled copper rods, wires and cables from the company's own copper. This step marks a new industrial development in that a mining company is now fabricating its own copper. "From Ore to Finished Product", the consumer is offered the benefit of continuous supervision of production from the mining of the ore to the drawing of the finished wire, a quality of service never before available to users of copper wire. The Anaconda mills are the only ones of their kind west of the Mississippi River. The advantages of this location are apparent when shipments to middle-western and western points are desired.

Rolling Rods and Drawing Wire

The first step in the fabrication of wire is the rolling of the copper rod from the wire bar. The wire bars are placed in a bar heating furnace and heated to a white heat. They are then passed through a series of continuous rolls, until it is lengthened from its original fifty inches to about one-quarter of a mile. The cooling of the heated copper in air oxidizes its surface. This oxidation is removed by submerging the rods in a bath of dilute sulphuric acid. The cleaned rods are now pulled cold through a series of chilled steel dies, each die in succession reducing the diameter until the required size of wire is obtained. For the finer sizes of wire diamond dies are used. The working of the copper hardens it and produces what is termed hard drawn wire. When soft drawn wire is desired the hard wire is passed through an annealing oven which renders it soft and pliable. In the production of medium hard wire it is necessary to anneal the hard wire at such a point in the drawing, so that additional drawing will bring the wire to the desired size.

The Anaconda mills are prepared to offer prompt shipment of telephone and telegraph wire, signal wire, tie wire, trolley wire and stranded copper conductors of any desired capacity. These materials are drawn to meet the specifications of the American Society of Testing Materials, but can be drawn to meet any other desired specification.

Trolley Wire Drawing Bench

Physical Specifications of Copper Wire Hard Drawn and Medium Hard

B. & S. Gage No.	Diam. in.	Area Circular Mils	Hard Drawn Tensile Strength lb. per Sq. in.	Hard Drawn Elongation in 10 in. per cent	M. H. Drawn Tensile Strength lb. per sq. in. Min.	M. H. Drawn Tensile Strength lb. per sq. in. Max.	M. H. Drawn Elongation in 10 in. per cent.
0000	0.460	211,600	49,000	3.75	42,000	49,000	3.75
000	0.410	168,100	51,000	3.25	43,000	50,000	3.6
00	0.365	133,225	52,800	2.80	44,000	51,000	3.25
0	0.325	105,625	54,500	2.40	45,000	52,000	3.0
1	0.289	83,520	56,100	2.17	46,000	53,000	2.75
2	0.258	66,565	57,600	1.98	47,000	54,000	2.5
3	0.229	52,440	59,000	1.79	48,000	55,000	2.25
				In 60 in			In 60 in.
4	0.204	41,615	60,100	1.24	48,330	55,330	1.25
5	0.182	33,125	61,200	1.18	48,600	55,660	1.20
	0.165	27,225	62,000	1.14	49,000	56,000	1.15
6	0.162	26,245	62,100	1.14	49,330	56,330	1.11
7	0.144	20,735	63,000	1.09			
	0.134	17,956	63,400	1.07			
8	0.128	16,385	63,700	1.06	49,660	56,660	1.08
9	0.114	12,995	64,300	1.02	50,000	57,000	1.06
	0.104	10,815	64,800	1.00			
10	0.102	10,404	64,900	1.00	50,330	57,330	1.04
	0.092	8,464	65,400	0.97			
11	0.091	8,281	65,400	0.97	50,660	57,660	1.02
12	0.081	6,561	65,700	0.95	51,000	58,000	1.00
	0.080	6,400	65,700	0.94			
13	0.072	5,184	65,900	0.92	51,330	58,330	0.98
14	0.065	4,225	66,200	0.91			
	0.064	4,096	66,200	0.90	51,660	58,660	0.96
15	0.057	3,249	66,400	0.89	52,000	59,000	0.94
16	0.051	2,601	66,600	0.87	53,330	59,330	0.92
17	0.045	2,025	66,800	0.86	52,660	59,660	0.90
18	0.040	1,600	67,000	0.85	53,000	60,000	0.88

Physical Specifications, Soft or Annealed Copper Wire

Diameter, in.	Tensile strength, lb. per sq. in.	Elongation in 10 in. per cent.
0.460 to 0.290	36,000	35
0.289 to 0.103	37,000	30
0.102 to 0.021	38,500	25
0.020 to 0.003	40,000	20

Data, Stranded Copper Cables
(U. S. Bureau of Standards)

Concentric Strands				VARIOUS METHODS OF STRANDING						
	Weight			Diameter in mils when composed of						
Capacity Circular Mils	Lb. per M ft.	Lb. per mile	Apx. Dia. Mils	3 Wires	7 Wires	12 Wires	19 Wires	27 Wires	37 Wires	61 Wires
1,000,000	3,057	16,142	1,152	....	378	289	229	193	164	128
750,000	2,293	12,107	998	....	327	250	199	167	143	111
500,000	1,529	8,070	813	....	267	204	162	136	116	91
250,000	764	4,036	575	....	189	144	115	96	82	64
4/0 B&S	647	3,416	528	265.6	174	133	106	86	76	58.9
3/0 B&S	513	2,708	470	236.7	155	118	94	79	67	52.5
2/0 B&S	407	2,148	419	210.7	138	105	84	70	60	46.7
1/0 B&S	323	1,704	373	187.7	123	94	75	62.6	53.4	41.6
1 B&S	256	1,351	332	166.9	109	83	66	55.6	47.5	37.0
2 B&S	203	1,071	296	149	97	75	59.2	49.7	42.4	33.0
3 B&S	161	810	260	132.2	87	66	52.5	44.1	37.7	29.3
4 B&S	127	674	232	117.8	77	59	46.8	39.3	33.5	26.1
6 B&S	80	424	184	93.5	61.2	46.8	37.2	31.2	26.6	20.7
8 B&S	51	267	146	73.9	47.1	37.0	29.4	24.6	21.1	16.4

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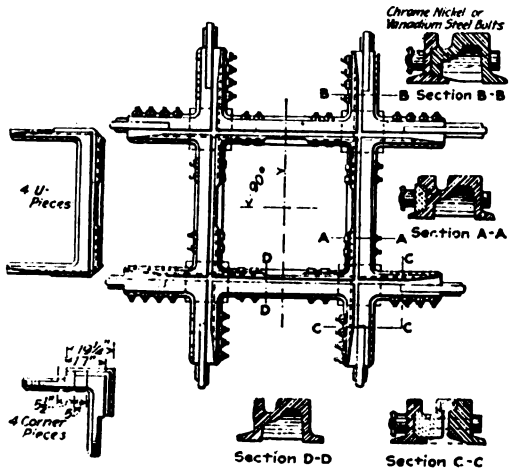
ARTICULATED CAST MANGANESE CROSSINGS

General

Articulated Cast Manganese Crossings are the culmination of a process of evolution and the final result of twenty-five years of experience and observation of failures peculiar to the various other kinds of crossing frogs, by Stephen Balkwill, who has made this subject his specialty and is a foundryman, designer, pattern-



Balkwill Articulated Cast Manganese Crossing—Details

maker, and was for twenty-two years connected as engineer in an executive capacity with one of the oldest crossing companies in the United States.

In the early stages of railroading, it soon became apparent that rolled rail crossings were not good enough to withstand the rapidly increasing punishment they were subjected to, due to the constantly increasing traffic consisting of extreme speed, continually greater loads plus increased frequency of trains.

The best present day rolled rail crossings at approximately 90 deg. contain about one hundred or more pieces of rolled rail and soft fillers, including sixteen knee braces and assembled with eighty to one hundred bolts. This large number of pieces of soft metal wear upon one another so that they are constantly rattling loose and the track gang is continually tightening the bolts and tamping the ties.

The best metal for resisting wear in practical use today is manganese steel, and crossings having their flangeway intersections cast solid were tried of this material, but imperect treatment, segregation, cold shuts and shrinkage strains at flangeway intersections caused their early destruction, together with failures due to long arms which frequently broke off and interior joints which failed in two or four piece crossings which required about forty-four to sixty or more bolts in their assembly and a dozen or more pieces, depending on their design.

Balkwill Crossings

As a remedy, Mr. Balkwill invented and patented the articulated crossing, which consists of placing joints at the places where breakage formerly occurred in the solid crossings, hence the name articulated. These joints each consist of an interlocking tongue and groove having a ground fit and securely bolted together with heat-treated bolts not less than 1¼ in. in diameter, with castellated cube nuts and 40 bolts in a medium strength crossing, or 56 to 64 bolts in the Heavy Duty Type, all of which are 6 in. minimum height and cross section of metal thick enough so they cannot be broken under the traffic for which they are designed.

The Extra Heavy Duty Type is 7 in. high and ⅛ in. is added everywhere to the thickness of metal; also the bolts are increased to 1⅜ in. or 1½ diameter, but can be larger if necessary, and there are 64 of them.

These crossings consist of 20 pieces comprising 4 U castings, 4 corner castings, 4 knee braces and 8 rolled steel flare fillers. On account of the design of these crossings, they allow a slight amount of flexibility due to their elasticity, although they appear to be solid under passing trains. They have a large reclaim value because any section can be replaced if worn out by traffic sooner than the rest. The factory cost for production is practically the same as the solid cast type when adjustment charges due to failure are added to the cost of the solid type and an equal section of metal is used in both cases.

The Balkwill Manganese Crossing Company, Williamson Building, Cleveland, Ohio, has standardized detailed drawings which specify the minimum thickness of metal and strength which it recommends for different types of crossings and at all angles from 90 deg. down to 35 deg., a complete set of which will be furnished free of charge on request, and all crossing makers have them on file.

Not a single case of failure has occurred to crossings built in accordance with these details.

When desired, renewable inserts can be furnished either cast integral with corner castings or as a separate unit.

The following crossing makers are licensed to manufacture Balkwill crossings: the Ajax Forge Co., Chicago; the American Frog & Switch Co., Hamilton, O.; the Barbour Stockwell Co., Cambridge, Mass.; the Bethlehem Steel Co., Bethlehem, Pa.; the Buda Co., Harvey, Ill.; the Cincinnati Frog & Switch Co., Cincinnati, O.; the Elliot Frog & Switch Co., East St. Louis, Ill.; the Frog, Switch and Manufacturing Co., Carlisle, Pa.; the Indianapolis Switch and Frog Co., Springfield, O.; the Kilby Frog and Switch Co., Birmingham, Ala.; the Louisville Frog and Switch Co., Louisville, Ky.; the Morden Frog & Crossing Works, Chicago; the New York Switch & Crossing Co., Hoboken, N. J.; the Pettibone-Mulliken Co., Chicago; the Ramapo Iron Works, Hilburn, N. Y.; the Seattle Frog and Switch Co., Seattle, Wash.; the St. Louis Frog & Switch Co., St. Louis, Mo.; the Weir Frog Co., Cincinnati, O.; Wm. Wharton Jr. & Co., Easton, Pa.; and in Canada, the Canadian Steel Foundries, Ltd., Montreal, Que.; and the Canadian Ramapo Iron Works, Niagara Falls, Ont.

Several hundred articulated crossings of various types have been installed on nearly fifty railroad systems, and they are distributed to every part of the United States.

The life of a 64-bolt Heavy Duty Type Articulated Cast Manganese Crossing is equal to about four carbon rolled rail, three insert, two solid cast or two manganese rolled rail crossings, which in any case cost about twice as much as the Articulated Crossing.

BALKWILL MANGANESE CROSSING CO., CLEVELAND, OHIO

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The Erie Ditcher

Although the Erie Ditcher, made by the Ball Engine Company, Erie, Pa., was introduced for railway work only a few years ago, it has set a standard of ditcher efficiency which has already won for it the endorsement of a number of the leading railways of the United States and Canada, as is indicated by the fact that the Pennsylvania System has purchased ten of these ditchers, the Chicago, Burlington & Quincy five, the Louisville & Nashville five, the Canadian Pacific five, the Northern Pacific five, etc.

An Erie Ditcher Operating Between Two Dump Cars on Side Ditching Work

The Erie Ditcher has won a wide reputation among railroad officials through the unusual service rendered. This ditcher is appreciated for a higher standard in every detail of material and workmanship. The Erie machines have a number of exclusive features which add materially to their efficiency in service—such as the simple control, by only 3 levers; independent engines for hoisting, revolving and crowding. (The dipper can be pushed forward into the digging at any desired point, to cut a slope of any desired angle.) Accessibility: All working parts are easily accessible for every necessary adjustment. Strong construction. These ditchers have given steady, reliable service even in heavy rock work. When used on ordinary ditching or locomotive crane work, they work year in and year out, with practically no repairs.

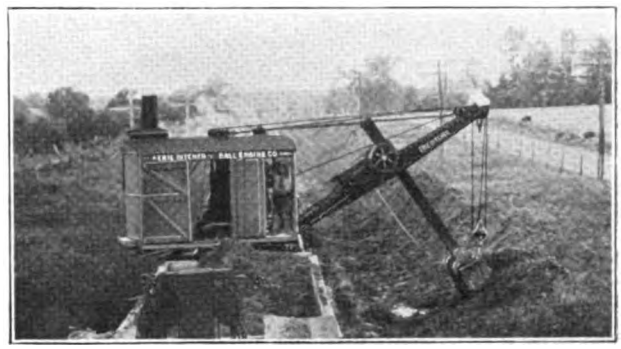
Mounted on Traction Wheels, Grading for Spur Extension

Uses

The Erie Ditcher keeps cuts well ditched for thorough drainage, working over a train of flat cars, or between side dump cars; clears up slides; excavates for scale pits, round house and shop foundations; widens grades for double tracking; removes materials or builds embankments for new spur tracks; grades for new road beds.

Excellent records for endurance in heavy rock work.

Officials estimate that the Erie is equivalent to 50 men and will do the work in about one-third of the time required by a gang of 50 laborers. One of the Erie Ditchers on the C. B. & Q., cleaning side ditches in light cuts, easily averaged 560 cu. yds. a day while keeping clear of trains. The official in charge wrote: "The Erie is far ahead of anything we have ever had on the Burlington." (Name of official on request.)

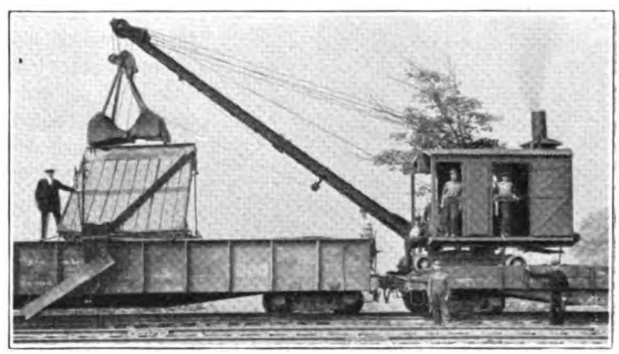


An Erie Ditcher Doing Wide Side Ditching Work

On the Renovo Division of the Pennsylvania, one of the Pennsylvania's 10 Eries loaded ten 60 cu. yd. hopper cars in a day. The official in charge wrote: "The Erie is far superior to anything we have ever used on the P. R. R." (Name on request.)

As a Crane

Any Erie Ditcher or Shovel can be quickly converted into a very efficient locomotive crane, and gives splendid results loading or unloading rails, poles, ties, scrap, bridge members, heavy timbers. Relays rails and shifts track. Operates a clam shell bucket to handle coal, gravel, rip-rap, cinders, etc.; coals locomotives.



An Erie Ditcher as a Crane, Cleaning Ballast.

The construction of the Erie Ditcher is simple, yet it is built far stronger than the usual standard of ditcher construction. Just for example: the rigid truck frame is formed from a single open-hearth steel casting, thoroughly annealed and heat treated. It is practically indestructible. The axles are forged from high carbon open-hearth steel. Throughout the machine there is an unusually high factor of strength to provide for the hardest service.

THE BALL ENGINE COMPANY, ERIE, PA.

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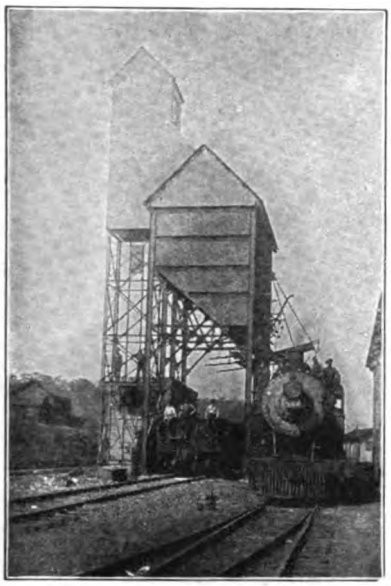
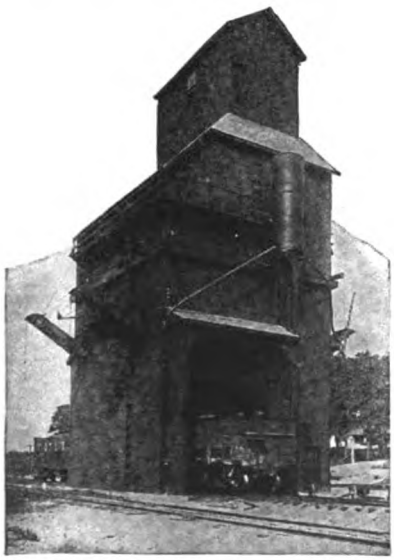
General

The Bay City Foundry & Machine Company, Bay City, Mich., is a manufacturer, engineer and contractor, and specializes in the design and construction of automatic locomotive coaling stations, made under the Williams, White & Co. patents. The plant also is located at Bay City, and the facilities embrace an engineering department, pattern shop, foundry, machine shop, forge shop and structural shop. In addition to machinery for coaling stations, the plant manufactures winches, cranes and capstans which are useful equipment in connection with motor truck transportation. The company has been for many years familiar with the problems of hoisting machines and has devoted its best energies to the design of these accessories of railroad maintenance.



100-Ton Steel Coaling Station, B. & L. E. R. R., Butler, Pa.

The coaling station is recognized by railroad officers as not only a labor-saving device but one whose presence is necessary to insure a regular supply of fuel and a convenient means for its delivery to the locomotive. The Bay City Company, in taking over the business of the Howlet Construction Company, which had for many years built coaling stations under the original patents, thereby attached to itself the accumulated experience and abilities of its predecessors.

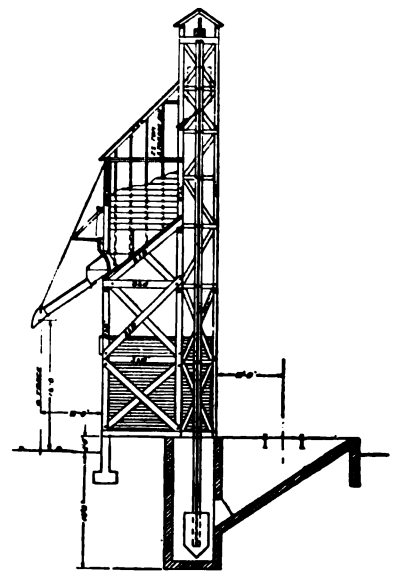


300-Ton Frame Coaling Station, St. L.-S. F. Ry., Lebanon, Mo.

Automatic Coaling Stations

The storage and delivery of coal to the locomotive, under present industrial conditions more than ever before, are required to be automatic in their operation. The Freeland, and the Williams, White & Company machinery employed by the Bay City Foundry & Machine Company in its numerous installations, are of that character. The company builds complete coaling plants, including facilities for the delivery of sand, and uses steel, concrete or wood construction as may be preferred.

The Freeland patent shallow pit bucket and a typical section for installation of this type of machinery are illustrated in the photograph. The Freeland Self-Loading Bucket is specially effective where soil conditions make deep pit coaling stations expensive to construct and maintain. This type of bucket permits of a pit being employed which is from 2 ft. to 5 ft. shallower than is ordinarily required, depending on the length and pitch of the hopper. The use of a feeder is eliminated in this type of coaling station.



Shallow Pit Bucket, Typical Section

The automatic feature of the Bay City coaling stations is supplied by the full cycle starter which enables the entire operation of elevating coal to be performed by one man. The power is supplied through a direct connected electric hoist, or through a belted hoist, which may operate from an oil engine, gasoline engine or steam power. A car puller is made a part of the installation when desired.

The hoisting bucket is made in three sizes, 1 ton, 1¼ tons and 1½ tons, and is furnished in single or double dump. The automatic feeder, where employed, is of the same size as the bucket. These two members are constructed of heavy materials and are guaranteed to furnish durable service. The buckets and loaders are designed to elevate coal at the rate of from 25 tons to 75 tons per hour.

1¼-Ton Shallow Pit Bucket, Freeland Patent

An equipment of sand valves and spouts and sand drying and screening apparatus is made a part of the installation when desired.

BAY CITY FOUNDRY & MACHINE COMPANY, BAY CITY, MICH.

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PORTABLE ELECTRIC DRILLS

General

The line of portable electric drills manufactured by the Black & Decker Manufacturing Co., Towson Heights Baltimore, Md., constitutes useful equipment in maintenance, both for bolt and bond hole drilling in track and signal work, and for wood boring, a frequent operation in bridge and building construction. The extension of electric power mains, the increasing provision of portable power generating sets and especially the adaptability of these drills for drive from lighting circuits, make their use an expanding one on the railroads.

The Black and Decker drills have the patented feature of the *"pistol grip and trigger switch,"* which

Black & Decker ½-in. Electric Drill

enables the operator to control the tool by the touch of a finger, in addition to other exclusive features developed through years of experience. The tools are not only correct in performance, but they present an attractive appearance which promotes care in their use.

All Black & Decker products are covered by a guarantee against defective material and workmanship. The tools have established a reputation for efficient service and long life, and the maintenance of this reputation is a primary consideration throughout the company's organization.

The Black & Decker Manufacturing Company maintains branch offices in New York City, Chicago, Philadelphia, Pa., Detroit, Michigan, Cleveland, Ohio, Boston, Mass., Pittsburgh, Pa., San Francisco. European representation is had through its office in London, Eng., and distributors of the products are located in all the principal cities of the United States and Canada, as well as in many foreign countries.

The Pistol Grip and Trigger Switch

An exclusive feature of all Black & Decker portable drills is *"the pistol grip and trigger switch,"* referred to above which not only increases the efficiency of an operation, but makes the work easier for the operator. By this device the control becomes practically automatic and the workman's attention can be devoted entirely to the guiding of the tool, resulting in better centering at the start of the operation and in less breakage of drills.

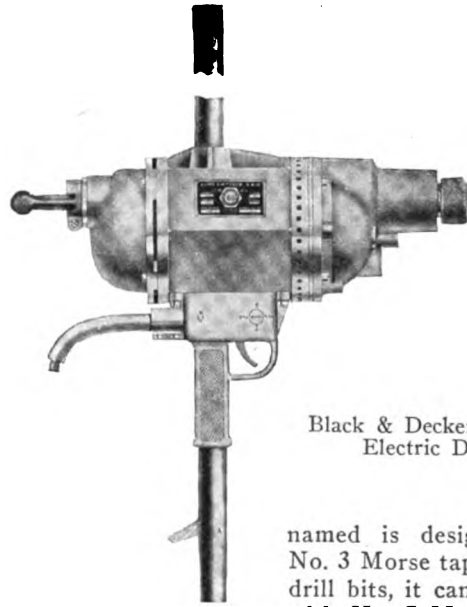
Besides its superior convenience, the trigger switch has many mechanical advantages. Since there are but three moving parts, the trigger, the pawl which engages the ratchet, and the revolving contact block, there is nothing that is apt to get out of order and make the drill useless when it is urgently needed. The contact blades are the springs which snap the circuit open with a minimum of arcing.

Details of the Drills

In the Black & Decker drills the drill spindle is offset for close corner drilling. The gear train is packed in grease in a separate compartment which requires repacking only four times a year. The motor, which is unusually powerful and built specially for these drills, will operate on direct current, on 25, 40, or 60 cycle alternating current, or on any two wires of a three-phase circuit. The motor is cooled by means of a centrifugal fan and will not become overheated under the most severe conditions of operation. The commutator end cover is independent of the motor bearing and may be removed easily for inspection or renewal of brushes. All parts in Black & Decker drills are absolutely interchangeable.

Sizes of Drills

The Black & Decker Portable Electric Drills are made in capacities for drilling steel from 3/16 in. to 1¼ in., the smaller sizes being adapted to bond wire drilling, and the larger sizes to bolt hole drilling. The capacities in hardwood boring extend upward to 2½ in. All these drills are complete with interchangeable spade handle and breast plates, with three-jaw chuck for straight shank drill bits up to the ⅝-in. size, and with Nos. 1, 2 and 3 Morse taper sockets, respectively, for the 9/16-in., ⅞-in. and 1¼-in. sizes. While the last



Black & Decker 1¼-in. Electric Drill

named is designed for No. 3 Morse taper shank drill bits, it can be used with No. 2 Morse taper shank bits by employing No. 2 to No. 3 Morse taper sleeve. A detachable side handle is supplied with the drills from ½ in. up, and a separable attachment plug with 15 ft. of duplex electric cable accompanies all sizes of drills.

THE BLACK & DECKER MFG. COMPANY, BALTIMORE, MD.

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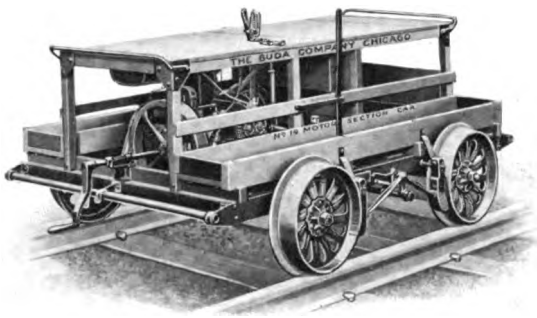
General

The Buda Company is one of the largest manufacturers of a complete line of track appliances in the world. The quality of Buda products is evidenced by their use on over 98 per cent of the railroad mileage of the United States. Since its establishment in 1881 and throughout its more than 40 years of engineering and manufacturing experience, the Buda Company has maintained the prestige gained in producing and marketing products of a high quality.

BUDA ESTABLISHED 1881

Motor Cars

The Buda Company manufactures all standard types of railroad motor cars and is specially well equipped for this work, being one of the largest manufacturers of automotive gasoline engines for motor trucks. The No. 19 Motor Car shown is in common use on leading roads for section or bridge gangs. The engine is horizontal, two-cylinder opposed, four-cycle, air or water cooled, with four-inch stroke, developing eight horse power. The engine is started by cranking, independently of the movement of the car, and all parts are enclosed. The engine contains its own oiling system, consisting of a positive feed gear pump, delivering oil from pan to crank case from which all bearings and cylinders are thoroughly lubricated by splash. The ignition is direct geared high tension Eiseman magneto. The transmission is friction disc, giving a wide range of speeds, both forward and reverse. The cranking feature for starting the engine removes one source of accident common in starting motor cars in which men trip and fall while running with the car.



No. 19 Buda Motor Car

The No. 19 Motor Car carries from 10 to 12 persons, and is also equipped with a tool tray on each side.

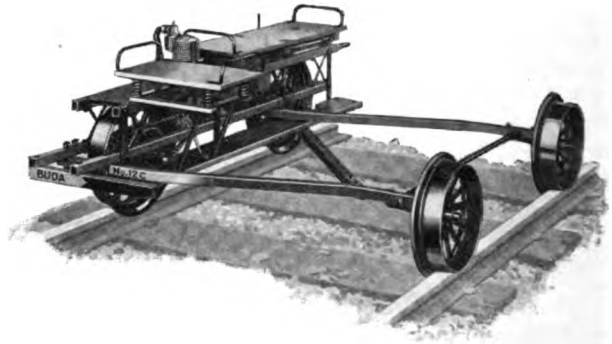
The No. 32 Motor Car differs from the No. 19 in that it is directly connected by a chain and friction sprocket, which allows the engine to pick up the load gradually. Buda patented rolled steel wheels are used on Buda motor cars.

No. 32 Buda Motor Car

Motor Velocipedes

Three styles of motor velocipedes are built by the Buda Company to meet all types of service. These have rolled steel wheels, and chrome vanadium steel axles, oil treated. Model No. 201, which is for one person, draws its power from a one-cylinder, four-cycle air-cooled engine, developing 2¼ horse-power, which drives the car from the front wheel by a chain running from a 9-tooth to a large 41-tooth friction sprocket. The No. 210 motor velocipede is the same as the No. 201 excepting that it has four wheels and carries two persons.

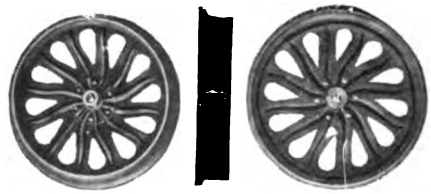
The Buda No. 12-C motor velocipede which carries three persons is particularly adapted for signal work. It is driven by a single-cylinder engine developing four horse power. Other types of Buda motor cars for inspection service and for bridge gangs, are of air and water cooled types.



No. 12-C Buda Motor Velocipede

Rolled Steel Wheels

Buda patented Rolled Steel Wheels are made from single plate open hearth flange steel. The reinforced tread provides a double thickness of metal at the point of greatest wear, and also provides a maximum of resistance to vertical load. The wheels are equipped with standard M. C. B. flanges.



Buda Rolled Steel Wheels

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Hand Cars, Hand Velocipedes, Push Cars

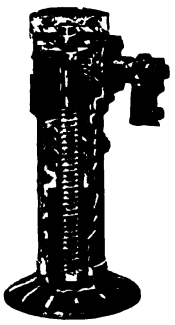
The construction and design of Buda Hand and Push Cars is in accordance with standard railroad practice. These cars have machine cut gears, taper fit steel axles, and rolled steel wheels. They are made in styles and capacities for every service and of all gages. Buda Hand Velocipedes are ball-bearing, light and easy running. They have rolled steel or wood center wheels. The wood construction is of the highest grade of white ash, combining strength and durability. These cars are furnished in four styles and of all gages.

Buda Hand Car

Buda Jacks

Buda Jacks are well known for their strength and lightness and the ease with which they may be handled. The ratchet jacks are constructed in many styles, up to 40 tons capacity, single or double acting, trip or automatic lowering, for track work and for car repairs. The No. 201 B Ratchet Jack illustrated is a double acting trip jack meeting all requirements of the Roadmasters' and Maintenance of Way Association. Its capacity is 10 tons with 13½ in. rise. All wearing parts are of high grade steel and the base is malleable. Buda Ball Bearing Ratchet Screw Jacks, for locomotive and car repair shops, bridge construction and general lifting purposes, are manufactured in capacities up to 75 tons. The bottom of the main screw is fitted with a nut which gives a "positive stop" when it is raised to the limit of height intended, thus preventing the possibility of damage by working the screw entirely out. All Buda Jacks are thoroughly tested before leaving the factory.

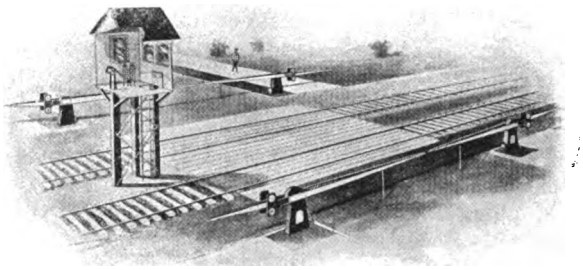
No. 201 B Jack



Buda Postop Jack

Crossing Gates

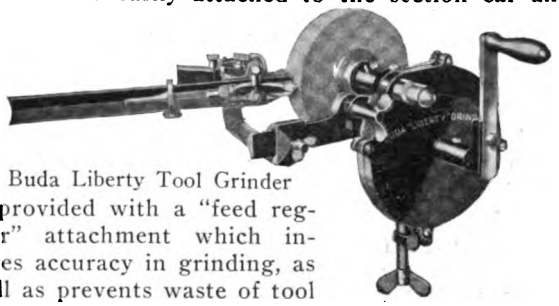
Buda Electric Crossing Gates are simple in operation, it being only necessary to throw a switch to raise or lower them, and they can be stopped instantly in any position. The Buda Company also makes Pneumatic (cylinder type) Crossing Gates, and the Bogue & Mills System Pneumatic Diaphragm types, as well as lever and crank gates and towers.



Buda Crossing Gate

Tool Grinder

Buda Liberty Tool Grinders are operated by hand, are portable and are furnished with attachments for grinding flat and twist bits, chisels, adzes, picks and scythes. The tool can be easily attached to the section car and is provided with a "feed regular" attachment which insures accuracy in grinding, as well as prevents waste of tool steel by grinding the tool too far on either side. This tool grinder is equal to many power machines and will perform the work of 20 grindstones.



Buda Liberty Tool Grinder

Drills Track and Bonding

Buda Hyduty Paulus Track drills are accepted as standard on many roads for bolt hole drilling in T-rails or girder rails. They are of over clutch or under clutch patterns, and are furnished with spindle and chuck for a flat drill bit or a round shank twist bit. The Paulus drill can be thrown back quickly to allow trains to pass.

Buda Hyduty Paulus Track Drill

Buda-Wilson Bonding Drill

Buda-Wilson Bonding Drills, equipped with the Liberty Clamp supersede the Hyduty-Wilson Drill introduced by this company in 1898. These drills clamp to the head of the rail and the drilling may be done before the rail is laid.

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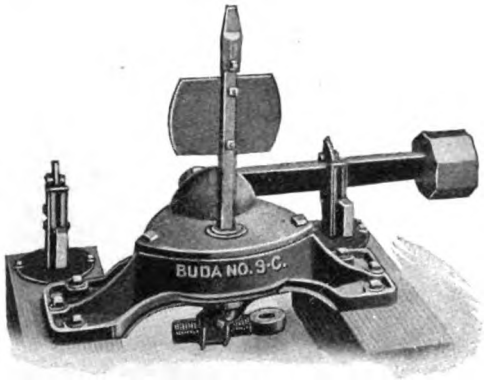
Switch Stands

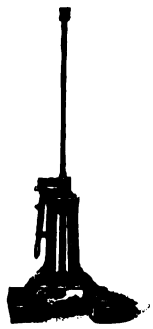
The Buda Company manufactures a complete line of switch stands for every variety of service, including automatic safety, semaphore, open base and ground throw types. The Buda 9-C Switch Stand is designed to overcome all backlash and is practically non-breakable. It is built along lines of simplicity as well as strength.



Buda 9-C Switch Stand

The height of the stand from tie to lantern tip is 21⅛ in. It can also be furnished with a target mast for use with a target lamp, the height then being 23 in. or any height desired.

The stands illustrated are the 9-C switch stand, the No. 22 open base high stand, and the No. 28 column base stand with target.



Open Base

Column Base

Buda Switch Stands

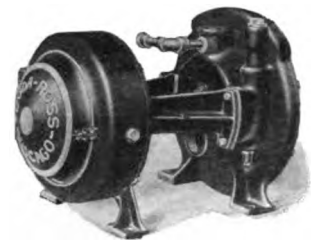
Track Tools

The Buda Company manufactures the Jim Crow rail bender, with or without cross bars, in types to bend any rail from 12 to 100 lb. The Roller Rail Benders are manufactured in four types to bend rails from 61 to 100 lb. The complete stock of Buda gages and levels will be found to meet any requirement arising in track work.

Buda Track Gage and Level

Headlight and Lighting Equipment

Buda-Ross Steam Turbo-Generators for locomotive headlights are well adapted for use as incandescent lighting plants on steam shovels, draglines, small boats, wrecking cranes, oil well derricks, cotton gins and isolated power plants. Wherever a steam pressure of from 85 to 200 lb. is available the Buda-Ross steam turbo-generator will prove an economical lighting plant. It is simple in operation and has no parts to get out of order, consisting of a steam-driven impulse type turbine directly connected to a one kilowatt, 110 volt, or a 32 volt direct current compound wound dynamo. The illustration is the model 1000-110 volt 1 kilowatt plant.



Headlight Generator

Special Work Frogs, Crossings Mates, Switches

The engineering department and shops of the Buda Company are well equipped to design and make all forms of special track work from simple split switches and frogs to the most complicated lay-outs, including all standard types of solid manganese, manganese center, and construction. The company also manufactures all types of mates, switches, frogs and crossings for both steam and electric railways.

Crossing Frogs

Girder Rail Switch

Bumping Posts

The Buda All-Steel Bumping Post combines strength, durability and convenience in installation with economy in maintenance. The only work required for installation is the drilling of holes in the rail, and the post can easily be moved to a new location if desired. This bumping post has been tested in service and has proved its value under severe conditions. Maintenance is practically eliminated in this post. Adopted as standard on a large number of railroads.

Buda Bumping Post

Car and Locomotive Replacers

Buda Replacers will give satisfaction under the most difficult jobs of rerailing cars and locomotives.

Outside—Buda Replacers—Inside

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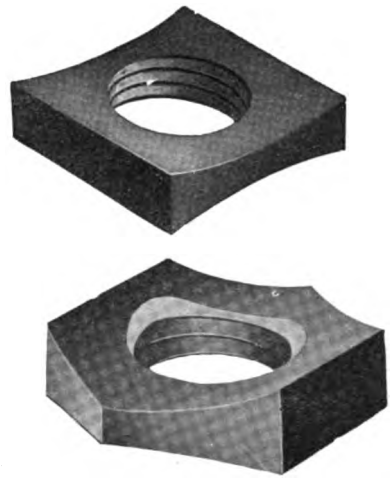
General

The need of a positive locking device is a live one, not only for railroad equipment, but also for frogs and crossings to insure increased wear and lower maintenance. This requirement can only be met satisfactorily by a device which is easily applied, requiring no special tools, which performs its duty effectively, and is at least as simple in design as the nut and nut lock which, in certain service, it replaces.

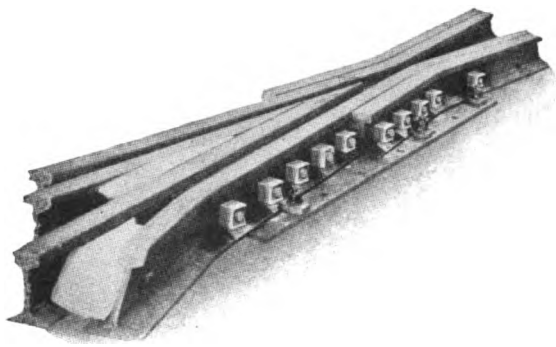
The Boss Lock Nut is intended to be used wherever a positive lock is required. The material carries with it the manufacturer's guarantee, both of material and workmanship. All nuts that are in any manner defective are replaced free of expense to the purchaser. This guarantee is possible by reason of the critical analyses of the steel used, the severe shop tests throughout the course of the manufacture and the rigid inspection given the finished product.

The Boss Nut Company, which has its factory and office at 1732-60 North Kolmar Ave., Chicago, in the heart of the manufacturing district, manufactures the Boss Lock Nut and offers its specialty in competition with other types of lock nuts or with nut and nut locks or double nuts.



Boss Lock Nuts

The Boss Lock Nut, being identical on top and bottom, may be applied in whatever way comes first to hand and may be run with the fingers as far as the holding nut. A further half turn with the wrench completes the application. The reverse of this operation removes the lock nut. By reason of the natural threads in the Boss Lock Nuts they may be applied to bolts, the heads of which are not held during the application of the nut, which effects a saving of labor in their use.



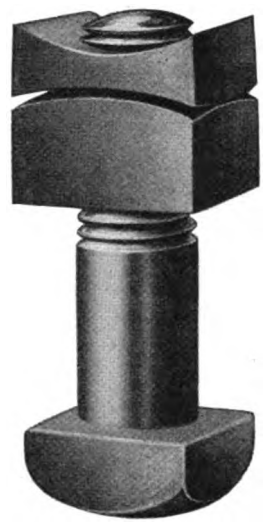
Frog Bolts Secured by Boss Nuts

Standard Boss Lock Nuts are made in either square or hexagonal patterns, and in size of nut varying by ⅛-in. increments from ¼ in. to ⅝ in. and from ⅝ in. to 2 in. by ⅛-in. increments. The Boss locomotive nuts are furnished rough, semi-finished and finished and in standard sizes 2 to 3 in. by ¼-in. increments. They are furnished in special sizes when desired. The threads regularly supplied are the U. S. standard, but others may be had.

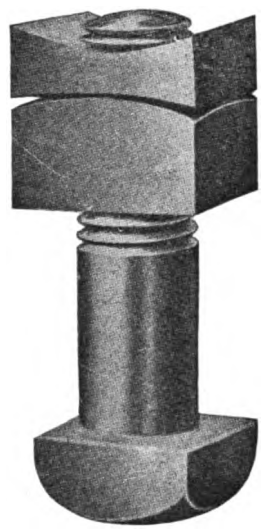
The Boss Lock Nut

The Boss Lock Nut is a single piece of steel, made into an auxiliary nut, with top and bottom surfaces concave and symmetrical about the two axes. It is tapped with a natural thread and is applied to the bolt more easily and quickly than the common nuts. After the sharp impinging edges of the Boss Lock Nut are in contact with the outer edges of the common or holding nut, a wrench is applied and the Boss Lock Nut is given from one-half to three-quarters of a turn, whereupon the bolt, common nut and the Boss Lock Nut interlock as one unit.

This result is attained by the grip introduced through the compression of the arch which causes the threads of the Boss nut to register deeply and firmly into the valley of the threads of the bolt, and its impinging edges to seize the primary nut firmly, so that all three are prevented from rotating in relation to each other. This operation does not injure the threads of the bolt, the common nut or the lock nut, and all may be used again with practically the same effectiveness.



Boss Lock Nut Unlocked



Boss Lock Nut Locked

While the Boss Lock Nut is primarily an auxiliary nut, the various sizes possess from 50 to 90 per cent of the strength of the bolts on which they are used, and it is possible in many applications to dispense with the common nut and use the Boss nut alone. The makers recommend that Boss Lock Nuts be used alone only on bolts that are subjected to shearing strains. An important feature of the Boss Lock Nut is that it locks securely on undersized or defective bolts.

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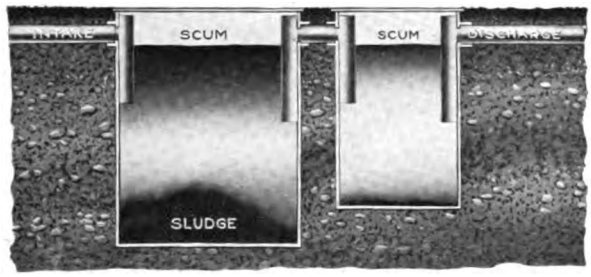
Perfection Septic Systems

Perfection Septic Systems are one of two classes of products of the Chemical Toilet Corporation, Syracuse, N. Y. They constitute a standardized system of the purification and sanitary disposal of the discharge from water-flushed closets.

The process of purification upon which the systems are based is a natural one involving the action of bacteria and is accomplished in the Perfection systems by confining the sewage in Perfection septic tanks, which are water tight storage chambers made of No. 14 gage Toncan iron, having all seams carefully welded, and having the interior and exterior surfaces protected from exposure to the various corrosive agents with which the tanks come in contact by means of a coating of special plastic enamel.

According to the company, the principles embodied in the systems are accepted as being sound,



Perfection Septic Tanks

practicable, and reliable by sewage disposal authorities. The company guarantees their quality, workmanship, and service qualifications, and states that any tank failing in service within five years will be replaced without charge.

The systems are light in weight, and can be handled and installed without difficulty. The company maintains them in stock at conveniently located points throughout the country in readiness for immediate shipment and through its service department is prepared to furnish interested parties with information relative to their installation.

Perfection Chemical Systems

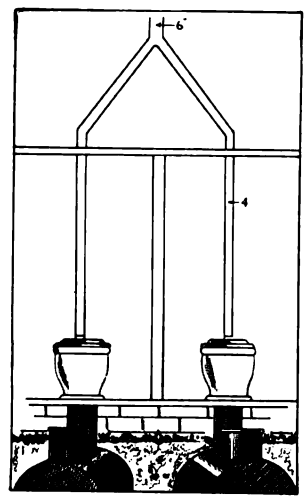
The Perfection Chemical Toilet Systems are designed for use in localities where running water is not available and are the direct outcome of the demand of the public at large and of labor in its assigned living or working quarters for facilities which contribute to their health and comfort. Through the existence of such systems, nuisances arising from improper sewage disposal and more frequently experienced but no less objectionable than in the watered localities, have been made preventable.

The Perfection Chemical Systems of the Chemical Toilet Corporation, Syracuse, N. Y., are based upon the immediate deodorization and liquefaction of the deposit within a large iron storage tank by means of a chemical thoroughly mixed with it by mechanical agitation. Proper ventilation is provided between the bowl and the roof, and a means is supplied of emptying the tank by pumping or draining.

These systems are suggested for installation at country stations, labor camps, and foremen's houses, at section headquarters, at watchmen's shanties and at all other isolated locations. The importance of providing sanitary toilets in connection with the operation of a railroad has become so well recognized as to require no comment. The difficulty of maintaining outside conveniences in a sanitary condition fully justifies the small expense necessary to install and maintain a satisfactory system.

The Perfection systems consist of four items: (1) Bowl and seat; (2) storage tank; (3) proper ventilation; (4) Perfection chemical. The bowl furnished is the Perfection vitreous china bowl with straight drop. The seat is a double-hinged oak or mahogany-finished seat, of semi-saddle design, with special doweled reinforcement. Ventilation is secured through a 4 in. vent with roof saddle and ventilator cap. The storage tank is of 128-gal. capacity and is made of Toncan iron, 99 90/100 per cent pure. All seams are welded.

The Perfection Chemical is a very powerful disinfectant, which deodorizes and liquefies all matter, whether animal or vegetable, preventing its putrefaction. Laboratory tests have shown the absence of bacteria or germ life of any kind where the systems are used. These systems are thus a practical safeguard against infectious diseases and furnish a logical, simple, safe way to dispose of sewage. The chemical may be obtained in large quantities direct from the manufacturer and shipped to division centers as needed, or may be purchased locally in small quantities.



Perfection Chemical System
Two Bowl Installation

The method of installing the Perfection systems is a simple one, and once installed according to the prescribed method and given the ordinary care and attention required by any similar equipment the systems are guaranteed to be fully satisfactory. Every Perfection storage tank is coated with plastic enamel, a special preparation which is highly resistant to the effects of high or low atmospheric temperatures, and to the action of the soil or atmosphere. The equipment is thus capable of a prolonged life. The company guarantees the life on a 15 year basis, the particulars concerning which will be furnished upon request.

CHEMICAL TOILET CORPORATION, SYRACUSE, N. Y.

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ANTI-CREEPING TIE PLATE

General

The Chicago Malleable Castings Company, (West Pullman) Chicago, Ill., manufactures the Thomas Rail Anchor Tie Plate, which is a combined rail anti-creeper and tie plate, and has a wide use on the railroads in these two services. The company manufactures the device also in Canada where it is represented by the General Supply Company, Ltd., with offices in the principal Canadian cities.

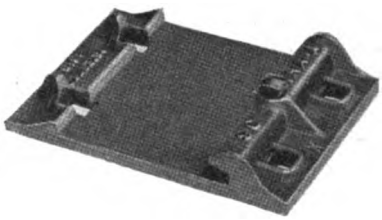
The Thomas Rail Anchor Tie Plate

The need for a device embodying the two features of a tie plate and a rail anti-creeper is a live one in track maintenance. The extending practice of treating ties, and the necessary use of many softwood ties of the non-treatment class, have brought about a largely increasing use of tie plate protection. The heavier traffic loads and accelerated speeds, have made it necessary to hold the rails against creeping, not merely as a matter of economy, but also of safety.

The Thomas Rail Anchor Tie Plate is primarily a tie plate, but differs from the ordinary pattern mainly in having a strengthened shoulder for one bearing of the rail base and a shoulder of a particular design for the other bearing.

The special shoulder is made in the form of a jaw having a wedging fit with the rail base, and is also equipped with a heavy set screw by means of which it may be clamped rigidly to the rail base. The outstanding feature of the other shoulder is the two lugs which back up the spikes, forcing a snug driving contact.

The Thomas tie plates are also made in a type adapting them to more than one width of rail base, so that these tie plates can be continued in use, even after the track is relaid with heavier rails. With this type any standard section of rail can be held in the same tie plate, the only change being in the size of the Osborn key which fills the space between the spike and rail base and is itself held securely by the spike. The full bearing of the spike against the key obviates all throat-cutting of the spikes.



The Thomas Rail Anchor Tie Plate

Thomas Plate as a Rail-Anti-Creeper

The Thomas plate has been designed specially to prevent rail creeping, which is due not to one cause alone, but to a combination of causes. In most places the chief factor is the wave motion of the track under the alternate application and release of a rolling load.

Sunlight and shadow are also very material forces to be considered inasmuch as the comparative states of heat and cold accompanying them give rise to corresponding expansion and contraction, which must of course be provided for. That this is a matter of common knowledge is attested by the general practice of establishing open spaces between the rail ends when laying them.

Frequently nothing effective is done to maintain the proper spacing. In fact methods of maintaining track tend often to vitiate the object which the spacing seeks to accomplish, inasmuch as rail ends are allowed to jam together and remain so, through the rigid hold of the joints tightly-bolted.

Tie Plate with Osborn Key

In order to prevent the creeping of rails and at the same time provide for the local movement due to expansion and contraction, each rail should be anchored in place when laid; the anchoring should operate in both directions; and the angle bars should allow the rails to move during expansion and contraction, thus maintaining the correct space between them.

The Thomas plate is specially effective in the anti-creeping feature because it prevents creeping in either direction and applies its resistance to each individual rail in the track. Its efficiency is made still greater through the rails being anchored thus upon every tie. The rail, tie plate, tie and roadbed thereby function as a whole to resist creeping.

The Thomas Plate as a Tie Plate

The two main functions of the tie plate are to save wear of the ties and to maintain the gage. The latter feature applies particularly on curves where the speed is usually greater or less than that for which the super-elevation was selected. In the one case the outer rail tends to turn outward and in the other the inner rail tends to turn inward. In the Thomas plate the jaws gripping the inside of each rail base resist this canting action and make the tie plate function as an extension of the width of the rail base.

The Thomas plate keeps the rails from moving with the traffic and also prevents any movement in the opposite direction. It holds each single rail in place rather than attempting to hold a section of track. Since the tie plates are secured to the ties they are not subject to the effect of snow, ice or frost.

The injurious effect of rails moving up and down under wheel loads is generally appreciated. When the rails and tie plates are not held together the moving load imposes severe impacts which tend to break the tie plate and distort the track structure generally.

Osborn Key
Full Size

The Thomas plate tends to control this vertical movement of the rails; for, as they are held rigidly to the tie plates and the latter are strongly secured to the tie, the movement must be of the track as a whole. The specific effect of this combination is a greatly stiffened track structure with the wave motion lessened.

The particular advantage of the Thomas tie plate in this regard has been specially demonstrated in the maintenance of track over swampy ground.

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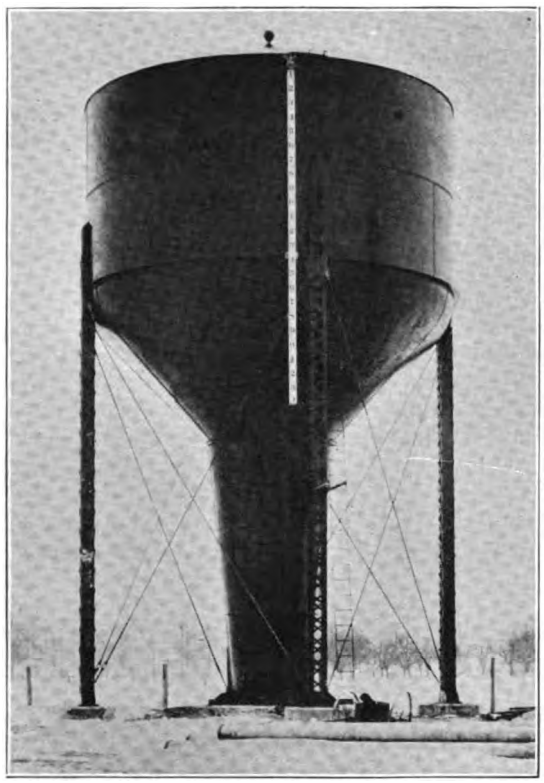
General

The Chicago Bridge and Iron Works is an engineering, manufacturing and erecting concern of international scope. It designs, fabricates and erects all kinds of structural steel plate work and commands a market not only throughout the United States and Canada, but also in Mexico and the countries of Central and South America. Its products applicable to railway service include locomotive service tanks for both water and oil, flat bottom storage tanks of all kinds, horizontal cylindrical tanks, steel coaling stations and bunkers,



Conical Bottom Type

self supporting smoke stacks, pipe lines and similar plate work. These products are fabricated with an attention to detail that assures the purchaser of a high grade quality of material and workmanship. Included in the structures built by the company in the past are a rolling lift bridge and a steel smoke stack which are the largest of their kind in the world.

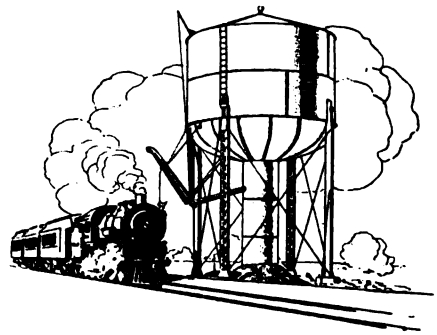
The Chicago Bridge and Iron Works is a concern of over 50 years' experience. It operates shops at Chicago, Greenville, Pa., and Bridgeburg, Ont., each of which is equipped for the production of all kinds of plate metal work, and is located advantageously with respect to sources of raw materials and transportation facilities. Sales offices are maintained at New York City, Chicago, Dallas, Tex., Atlanta, Ga., Charlotte, N. C., Los Angeles, Cal., San Francisco, Cal., Seattle, Wash., Bridgeburg, Ont., and Montreal, Que.

The engineering department of the company is prepared to submit, without charge, plans, specifications and estimates, and to give prospective customers the benefit of extended experience in solving structural steel problems effectively and economically. The company also handles its own field service and thus insures satisfactory work in all respects. Erection crews are at work in all sections of the country and can usually be sent to a location at small expense.

Railway Water Tanks

The Chicago Bridge and Iron Works has specialized in the manufacture of elevated steel tanks since 1892 when it built the first spheroidal bottom tank. Since that time the company has built thousands of steel tanks of various kinds at many locations in the United States and other countries which are typical of modern development in tank design. The types designed for general service and those designed more particularly for locomotive service have been adopted by the leading railroads for new installations and often as replacements for tanks of other materials. In a period of less than 20 years these tanks have come into extensive use on practically all large railroads, and are employed to a number in excess of 125 on a single line.

These tanks are fireproof and water-tight, and are constructed to last indefinitely with ordinary care and occasional painting. Owing to the long service insured by them and the small expense usually required for upkeep, a temporary increase in the initial cost of construction develops into an ultimate saving when maintenance is considered. Further advantages afforded by these tanks lie in the excellent service insured by them where conditions are ordinarily unfavorable for the maintaining of a suitable water supply. A condition of this kind often arises in sections of the country subject to protracted spells of cold weather. In these sections it is not uncommon for inlet or outlet pipes, although inclosed in frost boxing, to freeze up and the tank thereby to be rendered inoperative until thawed out,



Elliptical Bottom Type

an operation which is always expensive, and has resulted in the burning down of many tanks.

Another unfavorable condition is that often encountered in handling muddy water. At many points the railroad water supply for one or more of several reasons is obtained from streams or shallow reser-

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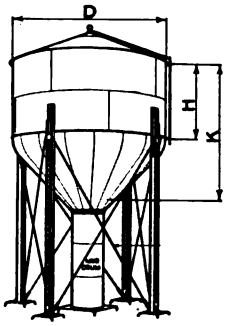


Capacity Thousand Gallons	Conical Bottom			Elliptical Bottom		
	D	H	K	D	H	K
15	15'-0"	8'- 0"	13'- 7"	15'-0"	9'-0"	12'-9"
20	16'-0"	9"- 9"	15'-11"	16'-0"	11'-0"	15'-0"
25	17'-6"	9'-11"	16'-11"	17'-6"	11'-0"	15'-4"
30	18'-6"	10'-10"	17'- 5"	18'-6"	12'-0"	16'-7"
35	19'-0"	12'- 3"	19'- 1"	19'-0"	13'-4"	18'-1"
40	20'-0"	12'- 6"	20'- 0"	20'-0"	13'-9"	18'-9"
50	22'-0"	12'- 7"	21'- 2"	22'-0"	14'-0"	19'-6"
60	24'-0"	12'- 2"	21'-11"	24'-0"	14'-0"	20'-0"
75	26'-0"	13'- 0"	22'-11"	26'-0"	15'-0"	21'-6"
80	26'-0"	14'- 3"	24'- 2"	26'-0"	16'-0"	22'-6"
100	28'-8"	14'- 2"	25'- 7"	28'-8"	16'-0"	23'-2"
125	28'-8"	19'- 4"	30'- 9"	28'-8"	21'-2"	28'-4"
150	33'-0"	15'- 9"	29'- 8"	34'-0"	16'-6"	25'-0"
200	36'-0"	18'- 0"	33'- 7"	38'-0"	17'-6"	27'-0"

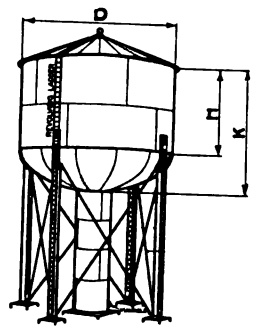
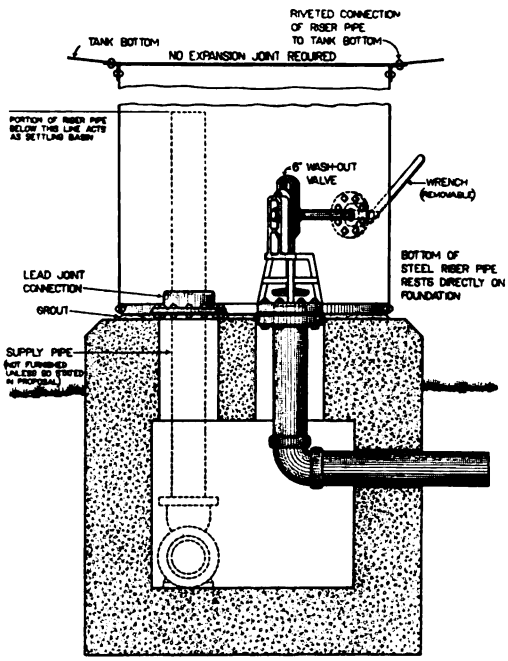


Table of Standard Dimensions of Locomotive Service Tanks

voirs which become especially muddy during some seasons. Where such water is pumped directly into the tank a large portion of the mud settles out on the bottom. Unless the tank is specially designed to prevent it, the mud rapidly accumulates around the outlet valve with a resultant mixing with the outgoing water, thereby aggravating engine troubles and increasing the cost of roundhouse service arising from the entry of mud into the locomotive boiler. Where tanks do not require outlet valves this trouble is sometimes avoided by a floating outlet pipe, but usually at the expense of pressure. Ordinarily the mud also accumulates on the tank bottom, where it reduces the effective storage of the tank at a time when this maximum space is needed for settling, and where it necessitates the cleaning of



Section of Steel Riser and Foundation

the tank, an operation which ordinarily requires taking the tank out of service and the employing of a crew of men. The Chicago Bridge & Iron Works has solved this problem by means of the self-cleaning feature of its tanks. The large riveted steel riser acts as a settling basin for mud and sediment in the water. This sediment is easily cleaned out by simply opening the washout valve and allowing the water pressure to force it out. The adaptability of these tanks to problems of this kind has often been a primary reason why railroads have installed them. They are also of attractive appearance, a consideration of increasing importance owing to the customary prominence of a tank about a station.

Canadian Special Type

For locations where low temperatures prevail for long periods, the company has brought out its "Canadian Special" type. An ordinary station stove is located in a compartment at the base of the riser. The heat rises through the tank by means of a 20 in. draft tube at the center of the large steel riser pipe, and at the top of the tank is permitted to circulate between the water surface and the roof. A two-ply frost case surrounds the riser, providing a 6 in. air space which is also heated by the stove. In this way the warm air reaches those portions of the tank most affected by the cold, and prevents the formation of ice around the outlet pipes, or valve mechanism. The tank valve is of an improved form and operated from below to prevent freezing. This type of tank is giving remarkable service on the railroads of Canada.

Other Types

Besides locomotive service tanks this company also builds high towers and tanks for water supply and fire protection of railroad shops, factories and industrial plants. Although standard plans and templets are always kept on hand, new designs for special conditions can always be made by the company's engineers.

Other Products

The Chicago Bridge & Iron Works also builds flat bottom storage tanks, horizontal oil tanks, self supporting stacks, riveted pipe lines, coal bunkers, coaling stations and similar plate work. The company has standards covering all sizes of storage tanks from the small horizontal tank to the large 55,000-barrel oil storage tank. Plates are kept in stock for the common sizes and quick delivery is thus assured.

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General

Chicago Pneumatic products and the company back of them need no introduction to railway maintenance engineers. For 25 years Boyer Pneumatic Hammers, Little Giant Air and Electric Drills and Wood-Borers, Chicago Pneumatic Compressors, Rock Drills and Giant Engines, have found extensive application through this important branch of modern engineering.

Chicago Pneumatic Service is now rendered world-wide in scope through Sales and Service Branches conveniently located in all important centers.

*Birmingham, Ala.	*El Paso, Tex.	*New Orleans, La.
*Boston, Mass.	Erie, Pa.	*New York, N. Y.
*Buffalo, N. Y.	Franklin, Pa.	*Philadelphia, Pa.
*Chicago, Ill.	Houston, Tex.	*Pittsburgh, Pa.
*Cincinnati, O.	Joplin, Mo.	Richmond, Va.
*Cleveland, O.	*Los Angeles, Cal.	Salt Lake City, U.
*Detroit, Mich.	*Minneapolis, Minn.	*Seattle, Wash.
*St. Louis, Mo.	*Montreal, Can.	Vancouver, B. C.
*San Francisco	Toronto, Ont.	Winnipeg, Man.

*Indicates branches maintaining stocks of complete tools and parts; also completely equipped repair departments.

Boyer Pneumatic Hammers

Boyer Pneumatic Hammers are the world's standard wherever rivets are driven. Divided into three distinct members, cylinder, handle and valve. Handles are interchangeable on all sizes of like type. Made in a variety of sizes to provide the right tool for any riveting hammer operation.

Sectional View, Boyer Long Stroke Riveting Hammer

All moving parts function in the same plane, in direct alignment with the operator's arm, permitting more and better work with less fatigue

SPECIFICATIONS. *STANDARD TYPE BOYER RIVETING HAMMERS

Size and Style	Piston Diam. In.	Lgth. Stke In.	Cpcty. Rivets In.	Weight Net lb.	Weight Shpg. lb.	Code Word
50	1 1/16	5	3/4	20	24	AARONICAL
60	1 1/16	6	7/8	23	29	ABACIST
80	1 1/16	8	1 1/8	25	32	ABACOT
90	1 1/16	9	1 1/4	26	33	ABACTOR
80x	1 3/16	8	1 3/8	25 1/2	32	ABACEPS

SPECIFICATIONS. *HEAVY TYPE BOYER RIVETING HAMMERS

60	1 1/16	6	7/8	26	31	ABACISTERN
80	1 1/16	8	1 1/8	28	35	ABACOTEM
90	1 1/16	9	1 1/4	29	36	ABACTUS

NOTE: Equipment with any of the foregoing hammers includes hose nipple and spring clip for holding rivet sets. Rivet sets furnished at extra charge when ordered.

*If desired any Boyer Standard or Heavy Type riveting hammer can be furnished with a closed handle having either inside or outside trigger instead of standard open type handle shown, at no additional charge. An inverted handle, instead of Standard Handle, can be furnished at an additional charge.

Boyer and Keller Calking and Chipping Hammers are built under the same exacting manufacturing standards as Boyer Riveting Hammers. Bulletin 600 contains complete information regarding these tools.

SPECIFICATIONS. *†BOYER "BK" CHIPPING AND CALKING HAMMERS

Size and Style Piston Diam., in.	Lgth. Stroke, in.		Service for Which Adapted	Net Wt., lb Shpg. Wt.,		Code—Round	Code—Hexagon
1	1 1/16	1	Light chipping	11 1/2	14	ABHUME	ABHURL
1-x	1 1/16	1 1/2	Med. chipping	12 1/2	16	ABIABIC	ABIACTION
2	1 1/16	2	Gen. chipping	13	16	ABIADUM	ABIDING
3	1 1/16	3	Hvy. chipping	14 1/2	18	ABIGAIL	ABILITY
4	1 1/16	4	Ex. hvy. chipg.	15 1/2	21	ABIOLOGY	ABIOLUS

SPECIFICATIONS. *BOYER CHIPPING, CALKING AND SCALING HAMMERS

F	1 1/8	1 1/4	Scal. hammer	6 1/2	10	ABJECTION	ABJECTNESS
BB	1 1/16	1 1/2	Flue beading	9	13	ABDOMEN	ABDOMINAL
B	1 3/16	2	Light chipping	12	16	ABDIQUER	ABDITARY

SPECIFICATIONS. *KELLER CHIPPING, CALKING AND SCALING HAMMERS

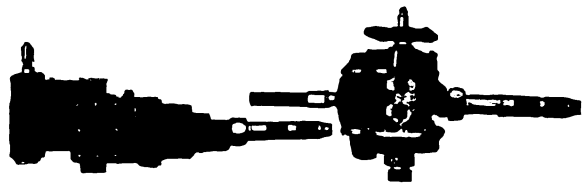
0	3/4	1 3/8	Scal. hammer	6	10	ABED	ABEILLE
‡	1 1/8	1 1/2	Scal. hammer	8	12	ACBELRIC	—
1	1 1/8	1	Light chipping	12	15	ABENSUR	ABERDEVINE
1-x	1 1/8	1 1/2	Med. chipping	13	16	ABERRANCE	ABERRANT
2	1 1/8	2	Gen. chipping	13 1/2	17	ABERRATION	ABERRING
3	1 1/8	3	Hvy. chipping	15	19	ABETTING	ABETTMENT
4	1 1/8	4	Ex. hvy. chipg.	16	22	ABEYANTLY	ABHOR

*When ordering, specify "Round" or "Hexagon" bushings. Chisels furnished at extra charge.

†In ordering, specify whether heavy or light type handle is desired. The heavy type is standard. ‡Valveless.

Little Giant Air Drills and Wood-Borers

For countless drilling, reaming, tapping, nut-and-bolt tightening, screw setting, flue rolling and countersinking operations. Powerful, sturdily built, compact and easily handled. Built in a wide variety of sizes and types to completely meet any requirements. Following table provides data on principal sizes. For information on the complete line, ask for Bulletin 598:



No. 91-R Little Giant Close Quarters Air Drill

No. 4 Little Giant Standard Air Drill with Feed Screw

SPECIFICATIONS. LITTLE GIANT AIR DRILLS

‖ † § Size No.	Speed Light, r.p.m.	Air Used ¶ per Min. cu.ft.	Socket*	Capacity° Drill—In.	Capacity° Ream	Capacity° Tap	Capacity° Flue Roll	Wt. Net, lb.	Code
10-F	2200	11	00	1/4	—	—	—	8	ABOBELLA
10-S	1000	7	0	3/8	—	—	—	8 3/4	ABOBESTIC
3-S (1)	1800	15	0	1/2	—	—	—	11 1/2	ABOCADLIC
3-RS (1)	1200	15	0	1/2	—	—	—	14 1/2	ABORINFELT
3-A (2)	800	15	1	5/8	—	—	—	12	ABOMASTER
4 (2)	800	20	2	5/8	1/2	5/8	—	22	ABOCAFE
4R (2)	360	18	2	7/8	1/2	5/8	3/4	24	ABOBRAND
4T	370	18	2	—	1/2	5/8	3/4	24	ABOBREATH
4C (2)	240	20	3	1 1/4	1 1/4	1 1/4	—	28	ABOBROOM
4RC (2)	125	18	3	1 1/4	1 1/4	1 1/4	2	30	ABOBRITISH
4TC	130	18	3	—	1 1/4	1 1/4	2	30	ABOBRIDE
2 (2)	480	25	3	1 1/4	1	1	—	40	ABOCALLA
2R (2)	325	20	3	1 1/4	1	1	2	42	ABOCABRA
12	325	20	3	—	1	1	2	44	ABOCABLING
2C (2)	155	25	4	2	1 1/2	1 1/2	—	52	ABOCALYX
2RC (2)	120	20	4	2	1 1/2	1 1/2	2 1/2	54	ABOCASTER
12C	120	20	4	—	1 1/2	1 1/2	2 1/2	56	ABOCAXTON
1 (2)	400	35	4	2	2	2	—	58	ABOCENTRIC
1R (2)	230	30	4	2	2	2	2 1/2	60	ABOCERVIX
11	230	30	4	—	2	2	2 1/2	60	ABOCEVIER
15 (2)	260	35	4	2	2 1/4	2 1/4	—	65	ABOCEDILLA
15R (2)	180	30	4	2	2 1/4	2 1/4	3	68	ABOCEFRON
15T	180	30	4	—	2 1/4	2 1/4	3	68	ABOCELERY
1C (2)	110	35	5	3	2 1/2	2 1/2	—	75	ABOCEREAL
1RC (2)	65	30	5	3	2 1/2	2 1/2	4	78	ABOCIMITAR
11C	58	30	5	—	2 1/2	2 1/2	4	78	ABOCIVIC
15C (2)	80	35	5	3			—	83	ABOCIBALD
15RC (2)	52	30	5	3			4	97	ABOCIRCUM
15TC	50	30	5	—			4	97	ABOCIGRAND

SPECIFICATIONS. LITTLE GIANT CLOSE QUARTERS AIR DRILLS

81	(3)	310	25	3	1 1/4	1	—	—	34	ABORIDEX
91	(3)	180	35	4	2	1 3/4	—	—	38	ABORIKON
81R	(3)	240	25	3	1 1/4	1	—	—	36	ABORIDEXTER
94R	(3)	120	35	4	2	1 3/4	—	—	40	ABORIKONISM
3		400	20	2	7/8	5/8	—	—	20	ABOREEOR

SPECIFICATIONS. LITTLE GIANT WOOD BORING MACHINES

10S	(4)	1000	7	—	3/4	—	—	—	8	ABORCATE
3RS	(4)	1200	15	—	1	—	—	—	14 1/2	ABOREXIS
3RSS	(4)	600	15	—	1	—	—	—	14 1/2	A"AGAYE
5	(5)	650	18	—	2	—	—	—	24	ABORBOON
5S	(5)	370	18	—	2 1/2	—	—	—	24	ABORELLO
14	(5)	700	20	—	4	—	—	—	32	ABORIMLET
14S	(5)	325	20	—	4 1/2	—	—	—	32	ABOROMA

*Nos. 00 and 0 indicate chuck sizes; other numbers indicate Morse taper sockets.

†Nos. in parentheses indicate the following regular equipment: (1) Breast plate and No. 0 chuck. (2) Feed screw. (3) Ratchet wrench for feed screw. (4) Grip handle and wood bit chuck. (5) Wood bit chuck.

‡Adapted for special extra heavy reaming and tapping.

§Letter "R" indicates reversible type drills; letter "C" indicates compound geared drills; letter "T" indicates drills fitted with grip handles and especially adapted for tapping, flue rolling or reaming.

°Drilling capacities are for drilling in metal—except wood boring machines, for which capacity in soft dry pine is given.

‖Nos. 10-F to 3-A inclusive, and No. 3 have 1/4-in. hose connections; Nos. 4 to 91-R inclusive have 1/2-in. hose connections.

¶At 80-lb. pressure.

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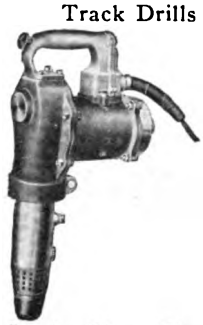
Little Giant Electric Tools

Little Giant Portable Electric Drills and Grinders are built with D. C., A. C. or "Universal" type motors, in a variety of sizes and types.

The Track Drill shown herewith is a semi-portable type for drilling and reaming track joint holes and is in wide use by electric and steam railways, wherever current for operation is available. It is 10 to 12 times faster and 90 per cent cheaper than old time hand methods.

Speeding Up Track Construction with Little Giant Electric Track Drills

Little Giant Portable Electric Drills
operate wherever there is a current outlet. Built in D. C., A. C. and "Universal" types



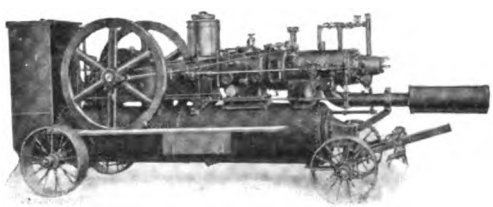
The Little Giant Electric Hammer Drill for drilling in concrete and soft stone; also for light chipping

The Little Giant Electric Hammer Drill, also illustrated herewith, is extensively used in drilling concrete and soft stone, as well as for light chipping of metals. Will drill holes in concrete or soft stone up to 10 in. Equipped with "Universal" motor, and may be wound for 110 or 220 volts.

The Little Giant Screw-Spike Driver is another electric tool now widely used by electric and steam roads which have found advantages in the use of screw-spikes. They are similar in construction to Little Giant Portable Drills, but are supplied with a specially designed circuit breaker which opens the circuit when the spike is screwed home. Operate from trolly, third rail or any convenient conductor. Furnished in D. C. or "Universal" types, 110, 250 or 600 volts.

Chicago Pneumatic Compressors

The Compressor with the "Simplate" Flat Disc Indestructible Valve. Built in 500 distinct sizes and types, including portable and stationary units for steam, belt, electric motor, oil, gas and gasoline engine drive, and in single, duplex and duplex tamdem types.



C-P Fuel Oil Engine Driven Compressor, Tank Mounted
Also available in stationary and skid mounted types

On construction work where dependable air power is required temporarily the tank mounted type illustrated, is one of several types available.

All Chicago Pneumatic Compressors are of totally enclosed frame construction have exceptionally liberal bearing surfaces, are automatically lubricated, have automatic regulation insuring maximum power economy under varying load conditions, and are of modern rugged design throughout.

Class O Duplex Motor-Driven Compressor, Capacity 1,145 cu. ft. per min.

Class N-SS Steam-Driven Compressor, Capacity 549 cu ft. per min.

Class N-SBE Short-Belt Motor-Driven Compressor, Capacity 392 cu. ft. per min.

Giant Oil and Gas Engines

The most economical form of power for isolated plants. Possess the overall operating economy of the full Diesel type without its complexity; the dependability of the steam engine without its costly auxiliaries; and the ability to operate successfully and economically on low-grade fuels.

Giant Oil Engines are guaranteed to run on petroleum distillate containing not more than 1 per cent sulphur or 25 per cent asphaltum, and ranging from 28 deg. Beaumé scale up to and including kerosene. They will operate satisfactory on many oils below 28 deg. Beaumé, depending upon the character of the oil.

Giant Semi-Diesel Oil Engine, Single Type, Capacity 60 H.P.

Single and Duplex types are built for operation on fuel oil in capacities from 12 to 200 H. P.; and in capacities from 16 to 160 H. P. for operation on gas.

Rock Drilling Equipment

Chicago Pneumatic rock drilling equipment includes Hand Hammer, Plug and Feather, Piston and Stoping Drills, etc., for percussive drilling; also air and electrically operated auger drills suited for soft rock formations, such as shale, slate, gypsum, etc.

Complete information on application.

"Hummer" Hand Hammer Drill
Powerful, easily handled, has independent rotation. Made in both wet and dry types

CHICAGO PNEUMATIC TOOL COMPANY, NEW YORK

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WEED KILLER

General

The Chipman Chemical Engineering Company, Inc., New York City, is the manufacturer of the Atlas line of weed killer, wood preservative, cattle and sheep dips, and various preparations for disinfecting stock cars, repellants, etc.

Atlas "A" Weed Killer

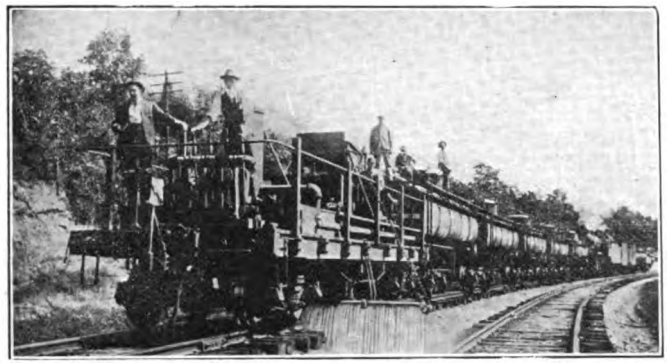
This product of the Chipman Company, which has been employed by the leading American and European railroads for several years, is a highly concentrated chemical, designed, as the name implies, to eradicate obnoxious vegetation. The chemical is clear, odorless, stainless, non-inflammable, non-explosive, and harmless to a sound skin if washed off. For eradicating weeds on driveways and paths of private estates, parks, cemeteries, etc., the chemical is put up in 150-gal. steel tanks, 50-gal. barrels, 5-gal. drums, and 1-gal. cans. In actual service it has demonstrated both the ability to destroy existing vegetation and to set up a condition in the soil which retards new growth.

Chipman Equipment

The most modern apparatus has been designed to cover 50 to 150 miles per day, thereby capable of treating long sections of track in a few hours without interrupting traffic or taking the section men away from their regular work. It effects a more lasting destruction of weeds, while eliminating the more cumbersome and expensive hand weeding and the fire hazard involved in burning weeds.

By employing this Service, railroads are relieved of much detail, avoid the need of owning equipment likely to be idle most of the year, and are assured of effective results economically. For railroads preferring to make their own applications, the company is prepared to furnish instructions for assembling the equipment and applying the chemical.

Before Treatment



Atlas "A" Service

105 Days After Treatment

Chipman Service

Atlas "A" Eradicator and Preservative is sold to the railroads for track work alone or as a part of the Chipman Company's complete service. This service takes into consideration every detail of weed killing, including the supply of chemical, sprinkling, apparatus and cars, and personal supervision of the work. The chemical is put up for shipment in tank cars of 4500 to 8000 gallons capacity.

As a weed killer, the chemical seeks to accomplish its purpose by attacking the roots of the weeds and the sprouting or seeding of growths in the soil. One treatment usually suffices for the season, and the indications are that the chemical, rather than injuring any part of the track structure, particularly the ties, exerts a preservative effect upon it. The period elapsing before the vegetation shows the effects of the treatment varies with the nature of the weeds and the character of the ballast, the first wilting occurring within 24 hours.

The chemical is prepared for treatment by adding water in the proper proportion and agitating until a uniform solution is effected. The proportion of water used is based upon the amount of chemical to be used per mile and the amount of solution required to thoroughly wet the surface and to penetrate the soil without puddling, variable according to the character and density of the vegetation; nineteen gallons of water to one of chemical is a common proportion. Where a fairly dense growth of ordinary varieties of vegetation prevail, 8 to 10 gallons of the chemical for each foot of track per mile is an approximate amount for the first year's treatment, decreasing with each succeeding treatment often by 20 to 30 per cent.

The equipment required for applying the weed killer depends largely upon the mileage to be treated. For work extending over 300 miles or more of track, the equipment prescribed by the Chipman Company comprises a train of tank cars and, at the front end, a flat car, upon which is mounted a sprinkling head, consisting of a system of pipes, mixing apparatus, and regulating valves, together with a centrifugal pump for filling the tank cars and forcing the solution through the sprinkler, also the power unit, and meters for measuring the supply of chemical and its consumption. The sprinkler comprises a system of perforated pipes carried under the flat car and extending crosswise of the track. It is divided into five independent sections, thus affording the means of varying the treatment over the track in accordance with the need for it, points of heavy vegetation getting more chemical, those of less vegetation, getting less. On less extensive work and where the locomotive is well equipped, sufficient pressure for sprinkling can sometimes be secured by introducing compressed air from the train line into the tank cars, while, for work between 25 and 150 miles of tracks it is usually sufficient to apply the chemical by gravity alone.

CHIPMAN CHEMICAL ENGINEERING CO., INC., NEW YORK CITY

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EXTENSION SIDE DUMP CARS

General

The maintenance-of-way department of a railroad is charged with keeping the fixed physical property in the best possible condition at all times. The maintenance of track and roadbed is of first importance; but, in addition, this department is called upon to furnish supplies of many kinds besides those which are primarily for track work. It also disposes of waste, of which no small part is ashes from stations, power houses and engine terminals.

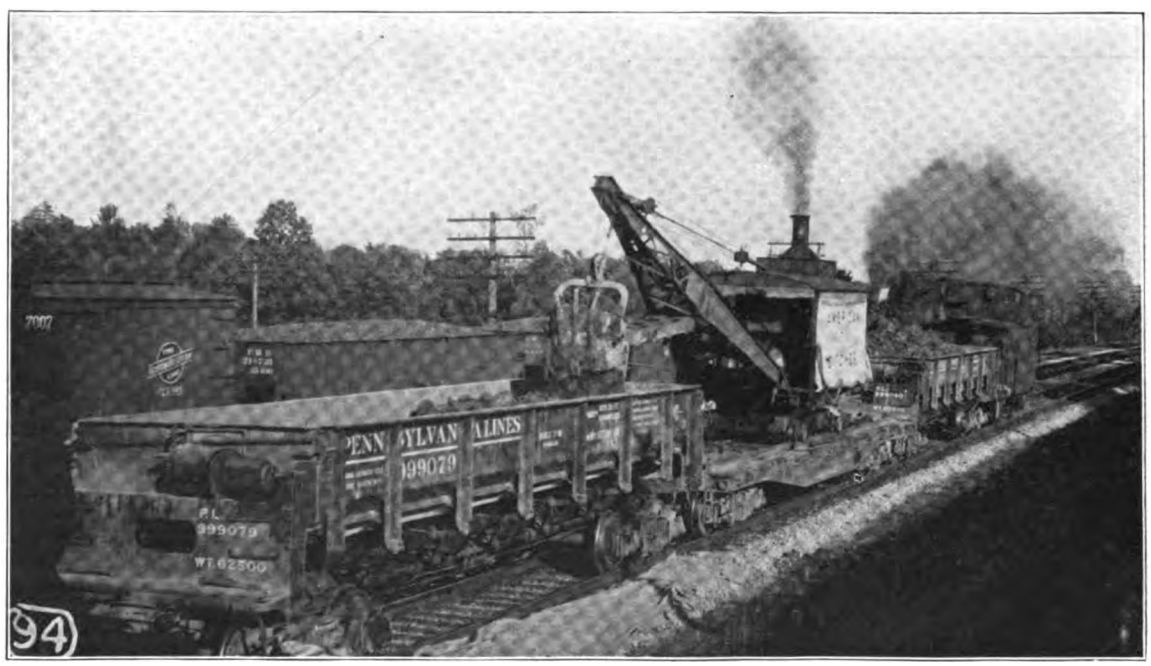
Labor has become so expensive, and maintenance materials have increased so greatly in unit weights, that the usual antiquated equipment assigned to work train service will no longer suffice. Efficient mechanical equipment must be provided if the fixed property is to keep pace with the ever-increasing weight and speed of trains. The steam crane and railway ditcher have already in a large measure replaced the man with the shovel; but it is only recently that the dump car has been recognized as the proper successor to the flat and gondola car in the work train. That the side dump car is receiving attention is attested by its special mention in one of the committee reports at the 1919 convention of the Roadmasters' and Maintenance of Way Association.

A side dump car for maintenance service should not merely be work equipment, but should be adaptable to regular freight service whenever pressing need requires. Indeed, even in maintenance service it is not an uncommon practice to deliver material to the maintenance department on one division from a supply department on another. If a dump car is the proper car for handling this material (as, for instance, gravel for a concrete viaduct), the dump car should be used, and of necessity must be an acceptable car for regular freight interchange.

Ditching Service

The economy of the Railway ditcher is universally recognized, and the further economy of placing a ditcher between two side dump cars is becoming so well recognized as to be regular practice on some of the railroads. The increasing density of traffic, decreasing the headway between trains, has materially reduced the time at the disposal of work trains for loading and unloading. An efficient dump car for a ditcher train must not only unload quickly, but completely; it must be unnecessary to touch the discharged load after dumping, either to allow movement of the dump car or to maintain clearance for following trains. When clearing up slides in cuts, large pieces of rock or tree stumps or even whole trees are frequently encountered. The railway dump car must be able to handle this class of material with absolute safety.

Car Will Handle Large Boulders



Ditcher Working Between Two Extension Side Dump Cars

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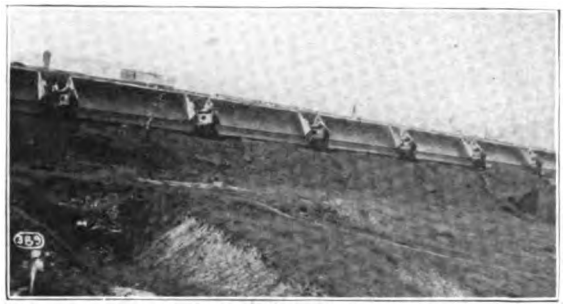
Ash Service

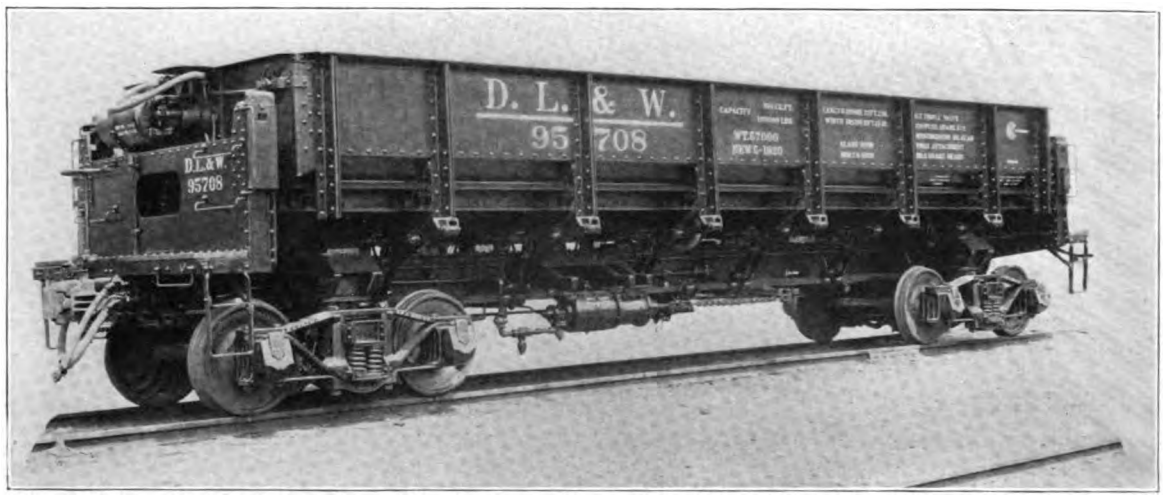
The disposal of engine terminal ashes is a day by day necessity, and for this service the side dump car is the proper equipment. The supply of ashes is usually constant in volume and a train of cars can therefore be spotted, loaded, dumped and returned on a regular schedule. The custom of loading ashes into any open type freight car that happens to be immediately available, and then unloading by hand, has reached a point where, by reason of congestion of traffic, scarcity of equipment, cost of labor and the definite time limits available, its further continuance is impracticable. The labor should be put on the track and the unloading done with side dump cars. This will not only materially benefit the track, but probably use the ashes where they otherwise would be thrown on a waste dump; and the saving in unloading costs will pay for the cars in a remarkably short time.



Dumping Engine Terminal Ashes

Supply Service

The maintenance department is frequently called upon to deliver coal to power houses, pumping stations and depots, or concrete ingredients to points similarly located, where side tracks are not feasible, and the supplies must be unloaded from cars on the main tracks. The time required to unload such supplies by hand is out of all proportion to the work performed, since it cannot be carried on continuously. The passage of regular trains causes the work train to move frequently and, of course, interrupts the unloading whenever such a movement is necessary. The building of a new concrete culvert often requires a temporary side track for the handling of the necessary supplies. If side dump car equipment is used for this class of work, the construction of temporary side tracks will generally be unnecessary, and the unloading labor costs and delays will be entirely eliminated, since the supplies can be dumped immediately and the work train released to attend to other work.



Extension Side Dump Car—Closed Position

The Extension Side Dump Car

The car illustrated herewith takes its name from the fact that the entire side of the car turns down and out coincident with the tilting of the body. This forms a chute over which the load in the car is discharged; and, the side being entirely out of the way, no obstruction is presented to the dumping of large boulders or tree stumps. Moreover, this extended side delivers the material well beyond train clearance, absolutely eliminating the necessity of a second handling to permit movement of the car or the safe passage of following trains.

The "Balanced Door" feature, inherent in all the Clark Car Company designs, is incorporated in the Extension Side Dump Car in such a manner that, when empty and released from the dumped position, the car closes by gravity and locks automatically. This balance feature also produces a dumping motion without shock to the track, and cars may therefore be safely dumped when in motion if desirable. The body is a separate structure supported over the underframe bolsters by rockers, and rolls to the side when dumping. The sides are hinged to the body along their lower edges and are further connected by toggle mechanisms under the car body floor, so designed that they hold the side upright when the body is closed and turn the side down as the body is tilted. Each mechanism is operated by a link connected to a latch hook located on the underframe. These links not only operate the mechanisms, but serve to lock the body in upright position.

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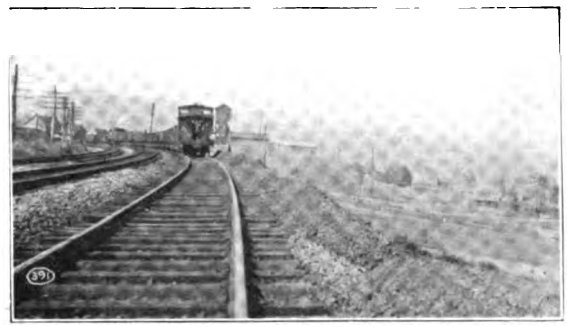
The car is dumped through the medium of compressed air supplied from a storage reservoir located on the car and charged from the locomotive. The air dump equipment throughout is arranged so as to be entirely independent of the brake system. The reservoir, with the proper initial charge, is of sufficient size to dump the car. Since each car has its own storage supply, the dumping of two or more cars as a unit is accomplished as easily as the dumping of single cars. Dumping is accomplished by the manipulation of a control valve located on one platform of each car, serving to charge or exhaust a separate train line on the car known as the operating line. Connection of the operating line between cars in a train allows the dumping of all the cars in the train from any one car.

The locks are operated by a separate air cylinder connected to the operating line through a cutout cock. Closing the cutout cock leading to any latch cylinder cuts out the dumping operation of that car. The body is tilted by two dump cylinders, one of which is mounted on each end of the body. The same pair of cylinders is used to tilt the body in either direction, reversal of dumping being effected by the simple process of swinging the cylinders around in a horizontal plane so that they push the body the other way. The locks are reversed manually, by means of a short pull rod which is located transversely of the underframe at the center of the car.

The Extension Side Dump Car in Maintenance

The peculiar characteristics of Extension Side Dump Cars making them effective in maintenance service, are size simplicity, safety, construction and efficiency of discharge. Their size makes them adaptable for general service work and efficient for handling coal, sand, gravel and ashes. The cars have a level full capacity of 30 cu. yd., giving a normal loading of 43 cu. yd., and carry 100,000 lb., based on the A. R. A. rating. The simplicity of the cars renders their operation and maintenance economical; for the operation is readily understood and repairs are made easily. The car is built strictly in accordance with A. R. A. rules and recommended practice, meeting all the requirements of standard railroad equipment. It contains all the safety appliances required by the orders of the Interstate Commerce Commission. In safety and construction, therefore, it is acceptable by the railroads as regular, and not special equipment, and for this reason is highly efficient, since it can be used in interchange service as a gondola under load. Efficiency of discharge elimi-

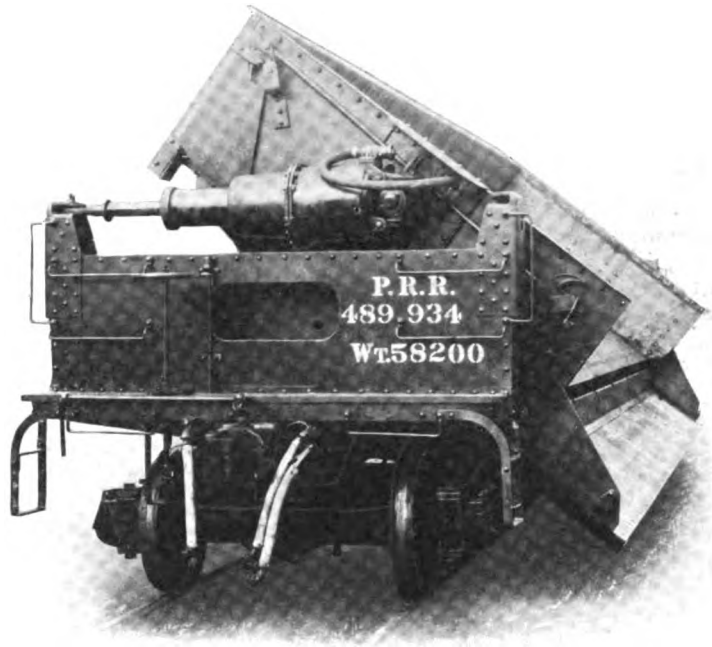


Train Clearance Always Maintained

nates that big problem in all maintenance work:—the man with the shovel.

Clark Car Company

The Clark Car Company has its main office in the Oliver Building, Pittsburgh, Pa. Branch offices are located at 683 Atlantic Avenue, Boston, Mass., the Peoples Gas Building, Chicago, Ill., and the Felt Building, Salt Lake City, Utah, where data on Extension Side Dump Cars is always available to anyone seeking information. A service department, operating from the Pittsburgh office, maintains a corps of trained engineers, whose assistance is available to customers at all times.



Extension Side Dump Car—Tilted Position.

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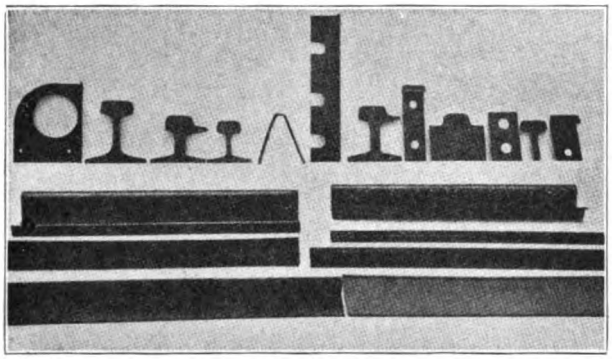
General

The Continental Fibre Company, Newark, Dela., is one of the largest manufacturers of vulcanized fibre and other compositions of an associated nature in this country. It has branch houses in New York City; San Francisco and Los Angeles, Calif.; Pittsburgh, Pa.; Chicago; and Toronto, Canada, and maintains offices and agencies throughout the world. Its products have been on the market for many years and in addition to railway track insulation, comprise a wide variety of shapes and grades of basic materials, and articles for all uses to which such material is now put.



Vulcanized Fibre and Continental Bakelite Articles for Track Insulation

Vulcanized Fibre

The Vulcanized Fibre, which is the Continental Fibre Company's most extensively used product in railway service, is a chemically treated, pure cotton cellulose, known on the market as fibre, hard fibre, and horn fibre. The company manufactures this material initially in the form of sheets, tubes, and rods, which, by machining and bending, are later formed into the various articles of commerce, such as end posts and fish plates for track insulation, switch rod insulation, etc.

The process of making the sheets consists of passing cotton rag paper through a strong acid or chloride bath and rolling it up on a large drum, whereon each layer of paper sticks to the layer beneath it. When the proper thickness is obtained the acid-soaked material is cut from the drum and into halves, thus forming the raw fibre. These sheets are then put through a succession of baths in which they are soaked and the acid finally leached out. After soaking, a process which occupies from a week to a year, depending upon the thickness of the sheet, the material is air-dried, all warps removed by heat and pressure, and then calendered, each sheet in its final form being hard and tough and firmly bonded. The vulcanized fibre tubes are made by a similar process except in being formed and dried on mandrels.

The Continental Fibre Company manufactures its fibre from high grade raw material and exercises a constant and careful control over each detail of its production. All the material is required to pass standard compression, tension, electrical, and other physical and chemical tests. The volume of this company's output of these materials is indicated by the fact that it carries a stock under normal conditions containing 1,000,000,000 lb. of finished sheets, and 2,000,000,000 ft. of finished tubing. For railroad service the company is prepared to furnish insulation to fit any insulated joint, and guaranteed to meet the standard specifications. The fibre used for this purpose is of a grade specially prepared for it.

Continental Bakelite

Continental Bakelite is the product of efforts specially directed by the company to providing the most satisfactory material for railway track insulation. When dry, fibre exhibits qualities of hardness, toughness, indifference to temperature changes, and electrical non-conductance to a degree that has very naturally qualified it for this use, but when soaked with water it swells up, softens, and until redried loses most of its mechanical and electrical strength. It was chiefly to provide a material equal to fibre when dry and at the same time less susceptible to water that Continental Bakelite was developed.

The material is made by hot-pressing canvas or cloth which has been saturated with raw Bakelite, a preparation which has become well established as the basic material of products combining the desired properties of fibre and hard rubber. Like fibre, the material is made up in sheets, tubes, and rods, the sheets being made by piling up layers of Bakelized canvas or cloth and heating under high pressure. In the process the Bakelite of each unit layer softens, making a solid mass of several laminations, and then hardens. After removal from the press, heat will not again soften it. Aside from the considerations of quality, an advantage of this material is the rapidity with which its manufacture can be accomplished, compared to that of fibre, by reason of which manufactures can adjust themselves readily to changes in the market, without carrying a large and correspondingly expensive stock.

Like dry fibre, this material is very hard, can be machined, is very tough, indifferent to all ordinary heat, and has high dielectric properties. But better than fibre, along with other properties, it is not subject to injury by contact with moisture. Where the best of fibre will soak up rapidly, Continental Bakelite will absorb only two per cent of its weight of moisture when soaked for eight days. The effect of its non-absorbing quality in track insulation is such that end posts will maintain their initial crushing strength of 40,000 lb. per sq. in. and also their high insulating value regardless of moisture conditions, whereas the strength of a fibre end post on soaking for a couple of days will usually drop from its initial value of 40,000 lb. to 10,000 lb., and will experience a corresponding lowering of its insulating value. From the standpoint of durability, it is claimed that the Continental Bakelite will outlast 9 to 17 sets of ordinary fibre insulation.

As a result the material is specially adapted for use where the highest quality of track insulation is desired. Bridge insulation, in particular, is one use in which it can be employed distinctly to advantage, Continental Bakelite affording in this field the means both of insuring dependable service over long periods and of materially reducing the unusually large expense involved in making bridge insulation repairs or renewals.

THE CONTINENTAL FIBRE COMPANY, NEWARK, DELA.

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General

The Corning Glass Works has devoted its entire attention to the development and manufacture of glass products for over 50 years. With its four large plants this company is the largest maker of technical glassware in the world. The main office of the company is located at Corning, N. Y., and a branch office is maintained in New York City.

Development in Glass

The efficiency of a signal system is no greater than the quality of the color or the strength of the glass employed for the night indications. With the adoption of red, yellow and green for the standard color indications, the necessity became apparent of increasing their range of visibility and of restricting the limits of hue to insure distinctness of each color. The laboratory of the Corning Glass Works has specialized in the development of high transmission glass for this purpose. Each piece of railroad optical glass which passes the rigid inspection throughout the routine manufacture is measured photometrically to insure uniformity in transmission value and hue. The Railway Signal Association specifications for lenses, roundels and glass slides were revised in 1918 to include this glass.

Corning Jars, Globes, Lenses, and Chimneys.

Corning Nonex heat-resisting glass was developed primarily to provide heat-resisting quality and greater mechanical strength for the lantern globe. Since its introduction in 1908 an enormous saving in breakage has resulted and a correspondingly increased safety of operation has been effected. In 1917 the Railway Signal Association incorporated heat-resisting glass in its lantern globe specifications.

High Transmission Lenses and Roundels

For the best indication of the switch, signal, marker and classification lamps a type of lens is required which is adapted to the particular use. The optical lens, which is most common, provides an intense beam in a limited area. The Inverted Lens with cover glass provides a similarly intense beam, but covers a somewhat greater area and is therefore preferable for certain conditions where an additional spread of beam is desirable. The Wide Angle Lens provides a light of relatively low intensity, covering an extremely wide area, and is most commonly used in connection with yard switches.

The Spreadlite Lens is a compromise between the optical and wide angle lenses, in that the rays from the light source are projected into a fan-shaped beam, having wide horizontal and narrow vertical dimensions, which thereby maintains a reasonably intense beam covering a wide horizontal area. This type of lens is specially useful in the switch and signal lights which are on or near curves, and it is also being used extensively in marker and classification lamps.

The Toric Lens is used exclusively in color light and position light signals, where a maximum beam intensity must be maintained for a long range daylight indication. Only sufficient light is refracted from the beam to provide indications at points from which the signal must be observed.

The Doublet Lens is used in connection with daylight color light signals, the combination consisting of two lenses arranged to receive a large percentage of the light transmitted and to provide a beam of large dimensions. Prismatic reflectors increase the beam candle power by reflecting through the light source, rays which would otherwise be wasted.

The convex type of roundels has replaced the flat type in order to gain additional strength and eliminate the troublesome effect of locomotive electric headlight reflections. The design includes a shoulder or bead located at the point where the flat flange and convex surfaces meet, thereby strengthening the glass considerably. Thin roundels or slides are pressed specially for use in classification lamps.

Nonex Battery Jars

The continuity of an electrical circuit is dependent upon the mechanical strength and heat-resisting qualities of the battery jar, which must also be of sufficient chemical stability to resist the action of a highly concentrated caustic soda solution. Corning Nonex Heat Resisting Patented glass was first developed in 1908, and since that time has given undisputed demonstration of dependable service. The battery jars made of this glass meet fully the requirements of the Railway Signal Association specifications.

Nonex Lantern Globes and Chimneys

The hard usage to which lantern globes are subjected requires a special type of glass and the proper conveying of signals depends upon a correct hue in the colored globes. Since this glass was introduced in 1908, breakage has been reduced approximately 60 per cent with a corresponding increase in safety of operation. In addition to a rigid visual inspection, each colored globe is photometered to insure proper values.

The useful life of a chimney depends largely upon its heat resisting qualities. Long time burner chimneys of all designs are manufactured by the Corning Glass Works and may be tested quickly for their heat resisting characteristics by heating in one spot with a match flame and plunging into cold water.

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General

The Crane Co., Chicago, manufactures valves, cocks, and fittings for every railway need. The company also handles valve, cock, and pipe fitting accessories; valve and pipe packing and coverings; pipe of riveted steel; cast and wrought iron; well casing, and tools for all pipe fitting requirements; water glass equipment; altitude, pressure, and vacuum gauges; steam, water, and air hose; steam and air whistles, etc. Established in 1855, the Crane Company has become one of the largest valve manufacturers in the world, its products for uses in handling steam, water, gas, air, oil, etc., exceeding 18,000 in number.

Factories

Chicago, Ill. Bridgeport, Conn.

Branch Houses—Warehouses—Offices

Aberdeen, S. C.
Aberdeen, Wash.
Albany, N. Y.
Atlanta, Ga.
Atlantic City, N. J.
Aurora, Ill.
Baltimore, Md.
Billings, Mont.
Birmingham, Ala.
Boston, Mass.
Bridgeport, Conn.
Brooklyn, N. Y.
Buffalo, N. Y.
Camden, N. J.
Chicago, Ill.
Cincinnati, Ohio
Davenport, Iowa
Denver, Colo.
Des Moines, Iowa
Detroit, Mich.
Duluth, Minn.
Evansville, Ind.
Fargo, N. D.
Ft. Wayne, Ind.
Grand Rapids, Mich.
Great Falls, Mont.
Hartford, Conn.
Indianapolis, Ind.
Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Little Rock, Ark.
Los Angeles, Calif.
Memphis, Tenn.
Minneapolis, Minn.
Mobile, Ala.
Muskogee, Okla.
Nashville, Tenn.
Newark, N. J.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Norfolk, Va.
Oakland, Calif.
Ogden, Utah
Oklahoma City, Okla.
Omaha, Neb.
Oshkosh, Wis.
Philadelphia, Penn.
Pittsburgh, Pa.
Pocatello, Idaho
Portland, Me.
Portland, Ore.
Reading, Pa.
Rochester, N. Y.
Rockford, Ill.
Sacramento, Calif.
Saginaw, Mich.
Salt Lake City, Utah
San Francisco, Calif.
San Jose, Cal.
Savannah, Ga.
Seattle, Wash.
Shreveport, La.
Sioux City, Iowa
South Bend, Ind.
Spokane, Wash.
Springfield, Mass.
Springfield, Ill.
St. Joseph, Mo.
St. Louis, Mo.
St. Paul, Minn.
Syracuse, N. Y.
Tacoma, Wash.
Topeka, Kan.
Terre Haute, Ind.
Tulsa, Okla.
Washington, D. C.
Watertown, S. D.
Wichita, Kans.
Winona, Minn.

Crane, Limited

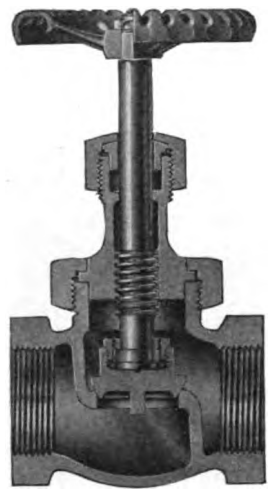
Calgary, Alta.
Halifax, N. S.
Hamilton, Ont.
London, Eng.
Manchester, Eng.
Montreal, Que.
Ottawa, Ont.
Quebec, Que.
Regina, Sask.
Sydney, N. S. W.
Toronto, Ont.
Vancouver, B. C.
Winnipeg, Man.

Crane Export Corporation

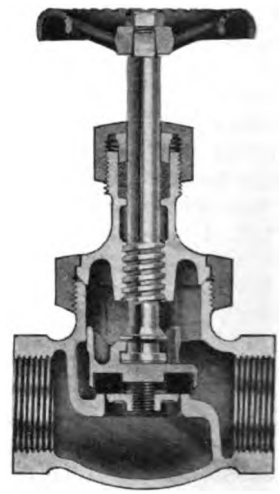
New York, N. Y. San Francisco, Calif.
Paris, France

Brass Globe, Angle, and Cross Valves

No. 70. Of the several brass globe and angle valves used in railway maintenance, this pattern, known as the Crane Navy Valve, is recommended by the company for all general uses in water service, on steam and hot water lines, stationary boiler connections, oil and air supply systems, etc. It is of heavy construction in Crane Special Brass and is equipped with packing gland, union bonnet, and "non-heating" hand wheel. It can



No. 70



No. 7

be packed when wide open under pressure and reground while in place, the operation of regrinding consisting of unscrewing the union ring, taking out the trimmings, inserting a wire or nail through the hole in the disc (which locks the stem so that both turn together), putting fine emery and a little oil on the disc, replacing the trimmings (leaving the large nut or union ring loose enough to turn the trimmings in the body), and thereafter grinding by rotating the trimmings until a tight joint bearing is formed on the seat and disc. The hub on the center piece guides the stem during the grinding. This valve is made in ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½ and 4-in. sizes in both globe and angle styles. Sizes 1¼ and smaller are designed for steam working pressures up to 225 lb.; sizes 1½ to 3-in., inclusive, for steam working pressures up to 200 lb.; and sizes 3½ and 4-in. for steam working pressures up to 175 lb. Cross valves of this pattern are furnished in ½, ¾, 1, 1¼, 1½, 2, 3, 3½, and 4-in. sizes.

No. 7. Valves of this pattern, a comparatively recent development, are designed for use in service where valve seats encounter unusual wear and tear and yet where leaks must be remedied immediately and quickly without injury to the valve. Instead of the regular valve seats, the valves accommodate a combination holder and disc of special design. The disc holder slips on the stem and is guided accurately in the body, whether the valve is open or closed. The disc or disc with holder are easily removed, the operation of repairing a leak consisting simply of removing the disc or, quicker still, the disc and holder, and inserting a new set. Discs of different compositions are furnished for different uses.

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thereby adapting it to special uses, discs of hard composition being used for steam, those of soft compositions for water, etc. The bodies are made of brass with stuffing box nuts and union rings of malleable iron. They are equipped with non-heating hand wheels and with packing glands, and can be packed under pressure. They are made in ¼, ⅜, ½, ¾, 1, 1¼, 1½, and 2-in. sizes; in globe and angle styles; for steam, air, and hot water working pressures up to 150 lb., and cold water service not subject to shock, up to 200 lb. Those sizes between ¾ and 2-in. are furnished screwed or flanged, and smaller sizes, screwed.

Brass Gate Valves

No. 440. Valves of this design are adapted for use in all general maintenance service. They are the rising stem type, have brass seats and body, a malleable hand wheel and parallel seats. The valve discs are self-adjusting, and are provided with central wedge to effect uniform seating. They are made in ¼, ⅜, ½, ¾, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, and 6-in. sizes, with screwed ends, and in 2, 2½, 3, 3½, 4, 5, and 6-in., flanged, for steam and water working pressures up to 125 and 175 lb., respectively.

No. 440

No. 437

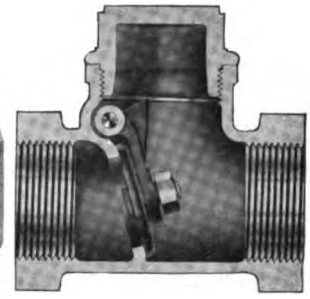
No. 437. Valves of this pattern are of the non-rising stem type. They are of heavier construction than the No. 440 and are rated accordingly for steam and water working pressures up to 150 and to 210 lb., respectively. They are made of standard brass, with gland, non-heating hand wheel, wedge gate, in ¼, ⅜ ½, and ¾-in. sizes, screwed, and 1, 1¼, 1½, 2, 2½, and 3-in. sizes, screwed and flanged. They can be packed under pressure.

Brass Check Valves

No. 20. This valve is adapted to all general horizontal steam and water service. It is made of brass and is rated for steam and water working pressures up to 125 lb. and 175 lb., respectively. The sizes are ⅛, ¼, ⅜, and ½-in., screwed, and ¾, 1, 1¼, 1½, 2, 2½, 3 3½, and 4-in., screwed and flanged. Sizes under ¾-in. are of the ball valve construction; those above, of the lifting disc construction.

No. 34. Swing valves of the No. 34 pattern are adapted to steam working pressures up to 125 lb. and water pressures up to 175 lb. They are made in ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, and 3-in. sizes, screwed. For use on steam lines the discs are of brass, for use in water service, of leather.

No. 20



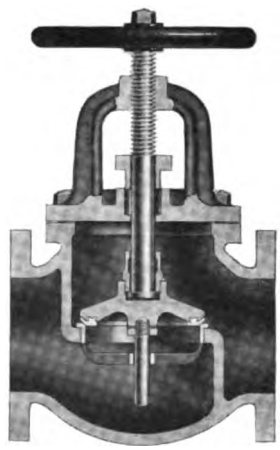
No. 34

Horizontal check valves can also be obtained in the renewable disc and malleable union ring construction, similar to the No. 7 pattern globe valves.

Iron Globe and Angle Valves

No. 351. Valves of this pattern are adapted to all general maintenance service on steam lines and in water service. They are of the standard construction, have a gray iron body with brass trimmings, outside screw and yoke, and rising stem. They are made in 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8, 10, and 12-in. sizes, screwed and flanged, and 14, 15, and 16-in., flanged, in globe and angle styles, for steam and water pressures up to 125 and 175 lb., respectively. These valves constitute a very moderately priced line of equipment.

Iron globe and angle valves for steam working pressures up to 175 lb. are also made of similar design, but with bodies of ferro-steel, and valve seats of Crane Special Brass.



No. 351

No. 461

Globe and angle valves are also made for steam working pressures up to 125 lb. which have a bonnet

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similar to brass valves, iron bodies, and the removable disc construction of the No. 7 type valves.

Iron Gate Valves

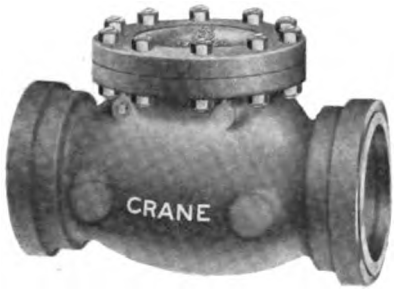
No. 461. Valves of this pattern are adapted to all general maintenance service. They are of the non-rising stem and wedge gate type, have an iron body with brass trimmings, and are made in 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8, 9, 10, and 12-in. sizes, screwed and flanged, and 14, 15, 16, 18, 20, 22, 24, 26, 28, and 30-in. sizes, flanged. Sizes 16-in. and smaller are rated for steam working pressures up to 125 lb. and water pressures up to 175 lb., and sizes above 16 in., for steam working pressures up to 100 lb., and water pressures up to 120 lb. Valves identical in construction except in having a yoke and outside rising stem, are also made.

Wash Out and Refill Valves

No. 393. Valves of this pattern are designed specially for service such as encountered in round houses on blow down, washout, and refill lines. They are made of extra heavy ferro-steel and accommodate a removable iron seat ring having its beveled seating surface on the outside, and a removable iron disc which, slipping down over the seat ring, tends to prevent the lodgement of scale, etc.

Foot Valves

No. 394. This valve is of standard construction, with an iron body, strainers, and leather discs. It is made in ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8, 10, and 12-in. sizes, screwed, and in 2-in. to 16-in. sizes, flanged. The sizes of 6-in. and under have hemispherical intakes, and those of larger sizes flat cylindrical intakes.



No. 375

No. 471

No. 393

No. 394

Iron Check Valves

No. 375. This is a clear way, swing check valve, of a pattern adapted to general service and accepted by the Underwriters for fire protection service. It is slightly more expensive than the standard patterns and is recommended for use where fire insurance questions are likely to arise. The discs are of leather or brass, as specified, and the bodies are provided with bosses for tapping in by-passes. It is made in 2½, 3, 4, 5, 6, 8, 10, and 12-in. sizes, screwed and flanged, for steam and water pressures up to 125 and 150 lb., respectively. Horizontal checks and other styles of swing checks are also made.

Quick Opening Valves

No. 471. This quick opening valve is designed for use in connection with water softening plants, slush pits, and similar service, where quick full opening and unobstructed flow is desired. Valves of this pattern have an iron body, with brass trimmings (including the sliding stem), and wedge gates. They are made in 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8, 9, 10 and 12-in. sizes, screwed and flanged, and 14, 15, and 16-in. sizes, flanged, for steam and water working pressures up to 125 lb. and 175 lb., respectively.

Radiator Valves

No. 124. This valve is adapted for use on radiators for steam service. The valves are of brass with wood handles and union radiator connections, and are of the renewable disc construction for facilitating immediate and quick repairing. They are made in ¾, 1, 1¼, 1½, and 2-in.

No. 124

No. 220

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sizes, with rough surface plated bodies, finished surfaced, and finished plated surface bodies.

No. 220. This pattern is an exceptionally high grade radiator valve for steam or vacuum systems, and has a self-adjusting packing feature. It is of the renewable disc construction, and has wood hand wheel. Other features embodied in the construction are a special stop construction in the valve to prevent jamming of the disc against the center piece in opening, and the presence of a coil spring in the end of the valve stem to take care of any shrinkage in the composition valve disc. These valves have given 10 years' continuous service in high pressure steam systems without leaking.

No. 520
Indicator Post

No. 50

No. 260

No. 962
Pressure Regulator

Non-Return Steam
Trap

Hose Valves

No. 50. Valves of this pattern are specially designed for use on building fire hydrants, and are regularly employed in railroad office buildings, warehouses, etc. These valves are entirely of brass excepting for the iron handle and leather valve disc. They are made in sizes from 1 to 2-in., inclusive, with the Chicago standard hose thread, the 2½-in. size having the Chicago fire department thread.

Cocks

No. 260. This design is one of several patterns of Crane cocks used in railway service. They are made of brass in ½, ¾, 1, 1¼, 1½, 2, 2½ and 3-in. sizes.

Indicator Posts

Indicator posts have as their object the providing of a convenient and dependable means of determining whether underground valves are open or closed. They are used principally in fire protection service, but may be used with advantage in other service, where important valves are underground. The device consists of a tubular, cast iron, adjustable post, made into sections, according to the depth. The valve stem is joined to a square operating rod at the top of which are two indicator panels under glass, marked "Open" and, "Closed." Turning the rod to the left exposes the "Open" indication, while closing the valve exposes the "Closed" indication. The indicator panels are adjusted to suit the valve. These posts are made in the standard pattern No. 520 and in a pattern conforming to the National Fire Protection Association specifications.

Pressure Regulators

The prevailing practice of obtaining steam and air from high pressure sources and the use of tools and other equipment whose effective operation require uniformity in the supply, have created a large need for automatic regulating devices. Suitable devices of this kind are often indispensable and can be employed most advantageously. The Crane Nos. 962 and 963 pattern regulators are excellently adapted for this work, embodying reliability, a wide range of variation in reduced pressure, simplicity in operation, accessibility for inspection, and convenience for repairing. They are made in ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, 6 and 8-in. sizes, for an initial air or saturated steam pressures up to 250 lb. They are adapted for use on steam heating systems, pumps, air tools, etc.

Steam Traps

The Crane Company manufactures three styles of tilting type steam traps, the Non-Return, Direct Return, and Three Valve. These traps will handle condensation from all sources and conditions of service and under any pressure of steam up to 250 lb. The discharging capacities of the traps are unusually large. The Direct Return trap, in addition to collecting the condensation, will return it directly into the boiler, delivering it as feed water without the aid of a pump. The Three Valve traps are designed to be used as lifting, vacuum, or metering traps, and are especially adapted for use on return lines handling condensation under varying pressures, especially where the pressure will vary from a vacuum to a high steam pressure.

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General

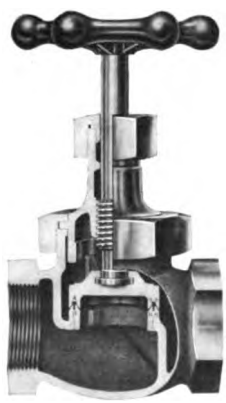
The Crosby Steam Gage & Valve Company, Boston, Mass., is the sole manufacturer of the Crosby appliances, which are employed extensively on the railways and elsewhere in the United States and in foreign countries for a wide variety of uses. The principal Crosby applicances employed in railway service are the Crosby spring seat, blow off, and safety valves, Crosby pressure gages, engine indicators, boiler test pumps, and steam whistles. In the maintenance field these appliances are adapted for use in heating plants, on stationary boilers, gas engines, pumps, etc.

The Crosby appliances are distinctly a high-grade class of accessories designed to meet a demand for equipment of a superior character. They are durably constructed by skilled workmen, made of carefully selected material, and are thoroughly practical in design. Where accuracy in operation or positiveness of action are desired, the appliances have been carefully designed to afford it, and whenever standards have been established to govern the quality or construction of equipment, these standards have been incorporated in the Crosby appliances wherever applicable. As a result all like parts are interchangeable and the appliances are specially adapted for their respective uses.

The Crosby Steam Gage & Valve Company is a manufacturing concern of long experience, having been established in 1875. Besides the general offices and factory in Boston it maintains stores in Boston, New York, Chicago, San Francisco and London.

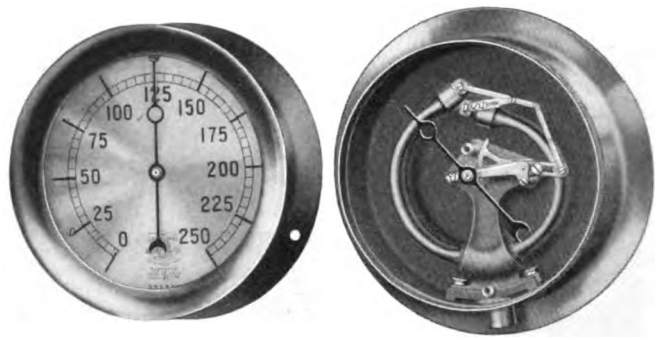
The Crosby Valves

The Crosby spring seat valves are particularly adapted for use on steam lines where their special construction affords distinct advantages in eliminating the expense and annoyance resulting from leaky steam valves on high pressure steam lines, radiators, etc. The special feature of these valves lies in the design of the valve seating. The face of each valve disc is given a V shape and each valve seat an inverted V shape, so that the disc telescopes over the valve seat when the valve is closed. Each face terminates at its apex in an annular groove of considerable depth, and the angle enclosed by the two faces of each disc is made slightly larger than the corresponding angle of the valve seat as a result of which the faces engage each other only along a single line of contact when the valve is closed. The presence of the grooves gives rise to a resiliency in the faces which, with the manner in which the faces fit together, permits perfect closure, and insures a tight joint even under sudden wide variations in temperature or the abrading effect of passing steam.



Crosby Spring Seat Valve

These valves are made in globe, angle, cross and check patterns, with bodies of brass, iron or steel, in various sizes, screwed or flanged, for medium or high pressure, and have all renewable working parts. The valve seats in all the valves are made of special Crosby nickel bronze which the company guarantees to be satisfactory for all working conditions including superheated steam. The other valve parts are made of different materials depending on the style of valve, but all materials are selected specially for their respective uses. The discs for the angle check valves and for iron valves over 4 in. in diameter are provided with a guiding stem to insure proper closure. All Crosby spring seat valves are required to pass a high pressure hydraulic test before leaving the factory.



Crosby Steam Pressure Gage

The Crosby Gages

The Crosby Company is particularly well known as the manufacturer of the Crosby gages, the accuracy and durability of which have been amply demonstrated under all kinds of service during the 50 years in which these products have been used. The same qualifications that are responsible for their extended use on locomotives recommend them to the maintenance department for use in registering steam pressure in stationary boilers, air pressures on tanks, and water pressure or altitudes at pumping stations.

These gages employ the principle of the Bourdon tube in their design, according to which pressure applied to the interior of a flattened bent tube closed at one end, tends to straighten it and thereby gives rise to deflections which can be transmitted by a system of levers to a graduated dial. By means of improvements allowed by Crosby patents of 1873, the Bourdon principle has been made applicable to all kinds and conditions of service.

Accuracy being the essential feature of all gages, every effort has been made to insure it in these gages. The method by which they are tested and graduated, insures a reliable instrument. Accuracy in operation is insured by the special construction of the tubes which affords sensitiveness without vibration of the pointer and prevents the "setting" of the mechanism under any pressure. The index mechanism is adequately protected by a heavy metal casing, but is independent of it. In gages intended for high pressures and temperature, the tubes are provided with screw joints, otherwise soldered, the screw joints co-operating with other features of the construction to insure reliability under the increased severity of service.

The gages are made in various sizes for high or low pressures and with brass, iron or nickel-plate cases. The Crosby altitude gage, designed for installation on pipe lines, etc., to denote the height of a

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column of water in a reservoir or tank, has its dial graduated to register in feet and is provided with two hands, the black or movable hand registering the height of water at any moment and the red or stationary hand indicating the limits of pumping, etc. These gages are used to distinct advantage where the pumping station is located at a distance from the water tank since they enable the pumper to tell at all times how much water is on hand. When specified, water gages can be provided to show, in addition to the height of water, the corresponding pounds pressure.

Gages for steam and water are also made by the company which by means of a mechanically actuated recording pen held in contact with a circular revolving chart, makes a continuous and permanent daily or weekly record of the pressure.

Steam gages operate best when the steam itself is excluded from the tubes. For this purpose the Crosby Company make siphons and siphon cocks which trap the condensed steam and permit it, only, to enter the gage.

Blow-Off Valves

The blow off valve in a steam boiler provides the only means of emptying it hot and, while the boiler is in service, of removing mud and precipitates periodically or of diluting a water highly concentrated with salts, thus avoiding foaming. Owing to their importance in this respect and the conditions to which they are subject such as unequal heating, tendency to clog or failure to close on account of scale, also the need of a free opening, good practice usually requires the use of valves specially designed for this purpose.

The Crosby Company manufactures two types of blow-off valves. They are the Johnstone blow-off and the Johnstone improved blow-off valves. The Johnstone blow-off valve is designed for use on stationary boilers and consists of a heavy iron body enclosing a gate valve of special design. The valve is opened and closed by the turning of a hand wheel or lever and when open offers a full straight passage through the valve. The valve is durable and protects the boiler from imperfect closure of the valve by preventing boiler scale, etc., from lodging in it. The valves are furnished in sizes from 1¼ in. to 3 in.

Blow-Off Valve

Other Crosby Products

Among other products manufactured by the company are the Crosby steam whistles, in common use on all types of steamships, in factories, power plants, on locomotives, etc., and in the smaller sizes are entirely suitable for use on pile driver engines, cranes, steam shovels, etc. They are known as the Original Single Bell Chime Whistles, and are distinctive in creating no annoyance from shrill tones. Consisting of a single cylindrical bell of three properly proportioned compartments, the sound is a soft and agreeable blending of the first, third and fifth tones of the musical scale and at the same time is penetrating and far reaching The whistles are made in patterns without whistle valves or with upright or side valves, with or without renewable valve seats, and in sizes having bells ranging from 1½-in. to 12-in. in dia. for ⅜ in. to 3-in. dia. steam pipes. Chime whistles are adapted for steam or air.

Crosby Whistle

In connection with these whistles the Crosby Company also manufactures an electrically operated whistle valve by means of which the whistles can be employed advantageously in connection with an automatic fire alarm system. The valve employs in its design an electro magnet which opens the valve and holds it open as long as the electrical circuit between the whistle and fire-alarm boxes is closed. The direct current required, the strength of which depends upon the steam or air pressure on the whistle, is obtainable from batteries or a generator. The valve is also provided with the usual lever for whistle cord opening. These devices are of simple and durable construction, instantaneous in operation, and entirely reliable.

The Crosby Company also manufactures indicators for registering the pressure in the cylinders of steam or gas engines while in operation. In these devices, movements of a piston under the cylinder pressure are transmitted to a lever carrying a recording pencil, and thence to a chart carried on a cylinder rotating in synchronism with the engine. The devices are very accurate and are widely used all over the world in shops, power plants and testing laboratories for determining the nature and efficiency of engine performance.

Another appliance of the Crosby Company used in the railway maintenance field is the Crosby pop safety valve for stationary boilers. This valve is similar in basic construction to the Crosby locomotive valves in common use throughout the country and is adapted for installation on stationary boilers of various kinds. The valve will not stick on the seat and is designed to open automatically only at the correct pressure. The design affords a wide opening and a free outlet as a result of which the boiler is relieved without undue loss of steam. It is attached easily and quickly and can be adjusted without removal. The valve is provided with a bell crank for opening by hand by means of which it can be operated as a relief valve as well as a safety valve. Crosby pop safety valves for stationary boilers are furnished in brass or iron bodies, and for low or high pressures.

Pop Safety Valve

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CORRUGATED BARS FOR CONCRETE REINFORCEMENT

General

The Corrugated Bar Co., Inc., Mutual Life Bldg., Buffalo, N. Y., with district sales and engineering offices in New York, Chicago, Boston, Philadelphia, St. Louis, Kansas City, Houston, Atlanta, Milwaukee, St. Paul, Detroit and Syracuse, has been established for more than 27 years. It has devoted its energies exclusively to the development of materials for concrete reinforcement, and to the designing of reinforced concrete structures. The products developed by this company are as listed below.

Corrugated Bars

It is the shape of the ribs on the Corrugated Bar that assures a perfect bond with the concrete, irrespective of the condition of the surface of the bar. This shape has been carefully determined; it is the result of scientific analysis and numerous experiments. The ribs bear squarely against the concrete, assuring full value of the tensile strength of every pound of steel used for reinforcement.

Careful tests by engineering experts of plain bars, twisted bars and various deformed bars have proved the type of bar represented by the Corrugated Bar to have the highest bonding value of any bar on the market.

Stocks of Corrugated Bars are carried in warehouses distributed throughout the United States. Thus prompt shipments can be secured.

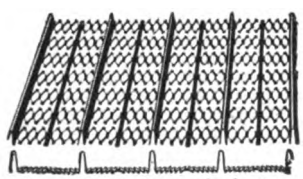
Corrugated Bars are carried in stock in the standard sizes having areas equivalent to:

Corrugated Bar

⅜ in. round, ½ in. round, ½ in. square, ⅝ in. round, ¾ in. round, ⅞ in. round, 1 in. round, 1 in. square, 1⅛ in. square, 1¼ in. square.

Corr-Mesh

Corr-Mesh is a very stiff-ribbed expanded metal—a one-piece product, made from the toughest and strongest sheet metal that can be produced. It is used extensively for walls and partitions, where it does away with extra studding. It forms a solid monolithic wall of great strength.



Corr-Mesh is made in two sizes—with ¾″ ribs and with $\frac{5}{16}$″ ribs.

For floors and roofs it acts as formwork as well as reinforcement. No centering is required.

Corr-Mesh replaces corrugated iron and mill construction for foundries and light manufacturing plants.

It makes handsome, permanent, fireproof railroad stations, sheds and wayside buildings at low cost.

In all these, and many other, uses Corr-Mesh is a great time, labor and money saver.

Beautiful Railway Station of Corr-Mesh

Corr-Plate Floors

Corr-Plate Floors are flat slab floors. There are no beams or girders to cut off the light, complicate the sprinkler, electrical and piping installation, or interfere with ventilation and heating.

Windows can be built clear to the ceiling, and the final finishing of the ceiling with plaster or paint is less expensive than with beam and girder construction.

Railway Terminal Warehouse—Corr-Plate Floors Used

The form work used in building Corr-Plate Floors is simple and inexpensive. The material is easy to place. On account of the scientific design, there is a great saving in amount of both concrete and reinforcing material used.

Lithograph Warehouse—Corr-Plate Floors Used

Corr-Bar Units

Corr-Bar Units are beam-and-girder-reinforcement shop-fabricated and assembled—all complete ready to place in the forms without necessity of bending or cutting on the job.

Corr-Bar Unit, Shop Fabricated—Ready to Place in Form

Shop-Fabricated Corrugated Bars

The Corrugated Bar Co., Inc., has excellent facilities for shop-fabricating Corrugated Bars to any form required, including spirals for column reinforcement. The use of Corrugated Bars shop-fabricated solves many labor problems on the job, insures the correct shaping of the bars and makes the matter of placing the reinforcement in the forms much simpler.

THE CORRUGATED BAR COMPANY, INC., BUFFALO, N. Y.

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General

The Diamond State Fibre Company, Bridgeport, Pa. (near Philadelphia), is the largest manufacturer of vulcanized fibre and vulcanized fibre parts. For over 25 years this company has manufactured railway insulating material and is

Diamond Fibre Standard Fish Plates

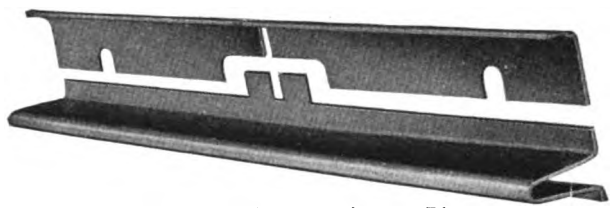
in a position to furnish every variety of such material for standard or special equipment.

The company's mills and factories are located at Bridgeport, Pa.; West Conshohocken, Pa.; Elsmere, Del.; Boston, Mass.; Chicago, Ill.; Toronto, Canada; and London and Maidstone, England. Sales offices are located in the following cities:

New York City	Philadelphia, Pa.
Chicago, Ill.	Boston, Mass.
Detroit, Mich.	Washington, D. C.
Cleveland, Ohio	San Francisco, Cal.
St. Louis, Mo.	Kansas City, Mo.
Indianapolis, Ind.	New Orleans, La.
Milwaukee, Wis.	Rochester, N. Y.
Minneapolis, Minn.	Houston, Texas
Toronto, Canada	Greenville, S. C.
London, England	Paris, France

Diamond-F Railway Insulation

With the increasing extent of installations of automatic block signals, insulating fibre has come to play an important part in railway signal equipment. Signal engineers in all



Diamond Fibre Continuous Plate

parts of the world have tested Diamond Fibre with results indicating its superiority as an insulating material. Diamond-F Railway equipment has become standard upon many important railway systems.

The properties of Diamond Fibre making it especially suitable for railway insulation are:

1. Its low initial cost;
2. The readiness with which it may be bent and punched to conform to the different shapes and styles of insulation used;
3. The ability to stand excessive pressure and vibration;
4. The toughness and density which gives it durability under all weather conditions;
5. Its superior insulating qualities.

Realizing the excessive wear and tear to which railway insulation is subjected, the Diamond State Fibre Company has developed a special grade of Diamond Fibre to meet railway conditions. The raw materials are carefully selected and the finished product is thoroughly seasoned and cured.

The Diamond State Fibre Company manufactures all of the many standard styles of railway insulation, and, as the requirements of the different roads vary considerably, it maintains a complete service for developing railway insulation to meet all special conditions.

The following types of railway insulation are regularly made and kept in stock for prompt shipment:

Braddock Plates	Switch Shims
Continuous Plates	Washer Plates
End Posts	Webber Angles
Fish Plates	Wiring Tags
Keystone Plates	Standard Fish Plates

Diamond Fibre is used extensively in the manufacture of numerous special parts employed by various railways, and bushings, washers, ferrules, gaskets, rings, dust guards, gage cock handles, liners and parts of every description are made in large quantities.

Diamond Fibre End Posts

Diamond-F End Posts

Diamond-F End Posts are leaders in this field of railway insulation. Signal engineers on many roads have standardized on this product and specify Diamond-F when making requisitions for end posts. They are made of a special grade of Diamond Fibre developed exclusively for railway work and contain the best material the manufacturers are able to obtain for this purpose. Diamond-F End Posts are not punched out but are individually sawed. While this is a more expensive process than punching, it protects the edges of the fibre and insures a longer and more efficient life for the product.

Diamond-F End Posts are made in a variety of styles and samples of this product as well as of standard designs of Diamond-F insulation for any railway purpose, will be furnished gladly for testing and experimental work. Orders for any kind of railway insulation should be accompanied by a blue print or sketch showing, wherever possible, dimensions, location of holes and any other specification that may be necessary.

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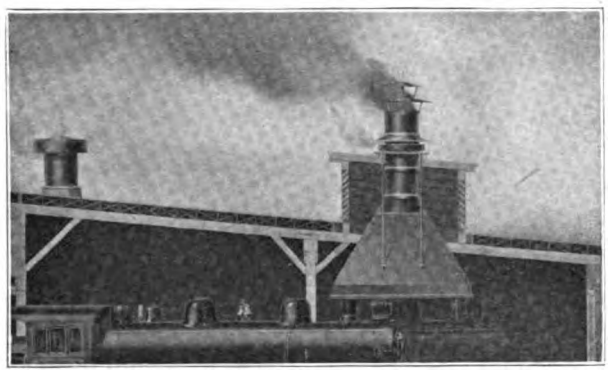
General

Paul Dickinson, Inc., 34th St. and So. Artesian Ave., Chicago, has specialized in the manufacture of sheet metal and cast iron roof ventilators and cast iron chimneys and smoke jacks for railroads for over 33 years. These products are made in types and sizes for use on large and small buildings, camp cars, engine houses, shops, etc., and embody a number of valuable features, particularly durability. They are widely used throughout the country, several thousand being purchased by the roads annually.

Smoke Jacks

For engine houses the corporation manufactures both the stationary open hood type and the telescopic type of smoke jacks. Jacks of the stationary hood type are made in a number of patterns for various types of buildings. All the patterns have rectangular hoods. These jacks are furnished in sizes having stacks of 20, 24, 30, 36, 40 and 48-in. diam. and hoods, 6 ft., 8 ft., 9 ft. 6-in., 10 ft., 12 ft., 14 ft., 15 ft. 6 in., and 20 ft. long and of heights suitable for the various standard buildings.



Engine House Equipped with Open Hood Smoke Jacks and Simplex Ventilators

Telescopic smoke jacks can be furnished in sizes having stacks 20 or 24-in. in diam. These jacks are particularly adapted to installations where the smoke from all engines is conducted to a central disposal point. They consist of the stack proper and a cylindrical hood, the latter being raised from or lowered over the engine stack by a simple system of levers and counterweights operated from the ground.

Camp Car Jacks

The company also makes a special type of jack for camp buildings and outfit cars. They are made for 5, 6, and 7-in. stove pipe and provide ample ventilation to prevent overheating of any wood work at the roof line. The roof connection is rigid and is furnished in patterns for 1-in. to 12-in. and 2-in. to 12-in. roof slopes.

These jacks comprise durable and inexpensive equipment for this use.

Chimneys

The cast iron chimneys manufactured by the Dickinson Company are self supporting and have a roof connection which provides its own flashing, protects the wood work of the roof from fire, and is adjustable to any ordinary slope of roof. They are made in sizes for

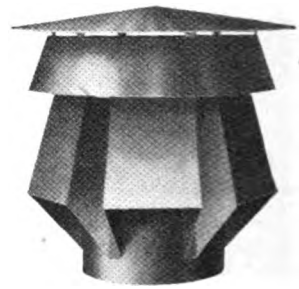
Camp Car Jack

Cast Iron Chimney, Adjustable to Slope

5, 6, 7, and 8-in. stove pipe and in two patterns, one for installation on the ridge, the other, on the slope of the roof. They can be furnished in any length above or below the roof connection.

Ventilators

The Dickinson Company manufacture two types of roof ventilators, the Aeolus and the Simplex. The Aeolus ventilators are distinctly adapted for use where a strong draft is desired, and are used regularly on engine houses, shops, foundries, and stations. In operation these ventilators employ the siphonic action of currents of air heated in and discharged upward through the converging flues on the sides of the stack. For installations where corrosive gases are encountered the ventilators are made of cast iron, otherwise of sheet metal. The cast iron ventilators are made in 20, 24, 30, and 36-in. diameters, the sheet metal in sizes ranging from 6-in. to 72-in.



Aeolus Roof Ventilator

The Simplex ventilators consist simply of a cylindrical cast iron stack surmounted by an overlapping drum. They are made in sizes ranging from 12 to 48-in. in diam. and have no movable parts.

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OIL CANS AND TORCHES

General

Oil Cans, Torches and similar Containers occupy a place of more importance in railroad service than the expenditures for them would indicate, and railroads can well afford to carry liberal supplies of suitable types of this character. This is particularly true where they are used for lubricating purposes, a service in which oil cans, if not indispensable, operate not only to overcome neglect to the fast moving machinery of railroads, but also to prevent waste of oil. In one or both respects, the benefits to be derived from their use greatly exceeds the initial cost and maintenance of equipment.

The Eagle Manufacturing Company, Wellsburg, W. Va., is manufacturer of a complete line of oilers, torches, supply cans, valve oil cans, fillers, etc., known as the Eagle line of Welded Steel Ware, built for railway service.

The Eagle Products

Its railroad products are widely used throughout the country, and are standard equipment on many of the largest railroads in America. They have been standardized because of the efficiency rendered in service.

The Company makes a special study of railroad oil can equipment. It has been engaged in the manufacture of these products for over twenty-five years and is now known as the largest of its kind in existence. It also manufactures a complete line of oil can equipment for mills, mines, foundries, and machine shops, agricultural and automobile equipment. It operates in connection with its plant, a complete printing department, which enables it to furnish helpful literature, catalogues, prints, sketches, etc., by which its products are fully described to the user. The lines embody the manufacture of oil can equipment in various finishes, enameled, copper-plated, brass-plated, tinned, and polished steel, ranging in capacity from one-fourth ounce to five-gallon sizes, in various designs and styles.

The Welded Steel products of the Eagle Manufacturing Company comprise a class of equipment of which the company is the originator and sole manufacturer. Oilers and other allied containers belonging to this class, present an indifference to heat and a ruggedness to rough usage to an exceptional degree, making them practically indestructible. In this respect they are particularly of interest to the railroads on which wear and tear on equipment is unusually severe, and where heat is often encountered sufficient to open the seams of ordinary equipment. In this field, the equipment has been used extensively for years and is the subject of service records fully in accord with expectations. The process of manufacture involved is that of welding all seams instead of brazing, soldering, or riveting. As a result, each product is transformed into a strictly one-piece article, embodying characteristics identical to a container made from a continuous unbroken sheet of steel.

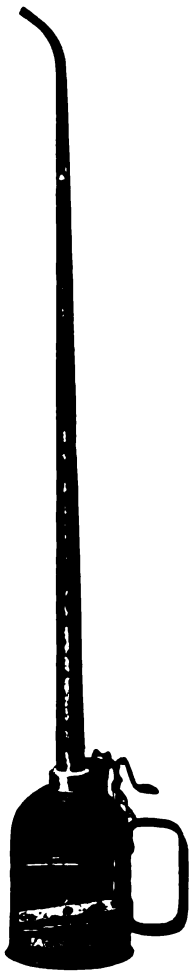

Fig. E400

Fig. G2-110

½ Gal. to 5 Gal.

Fig. E100

Fig. E145

Fig. E40B

Fig. E81R

Miscellaneous Kinds of Eagle Oil Cans

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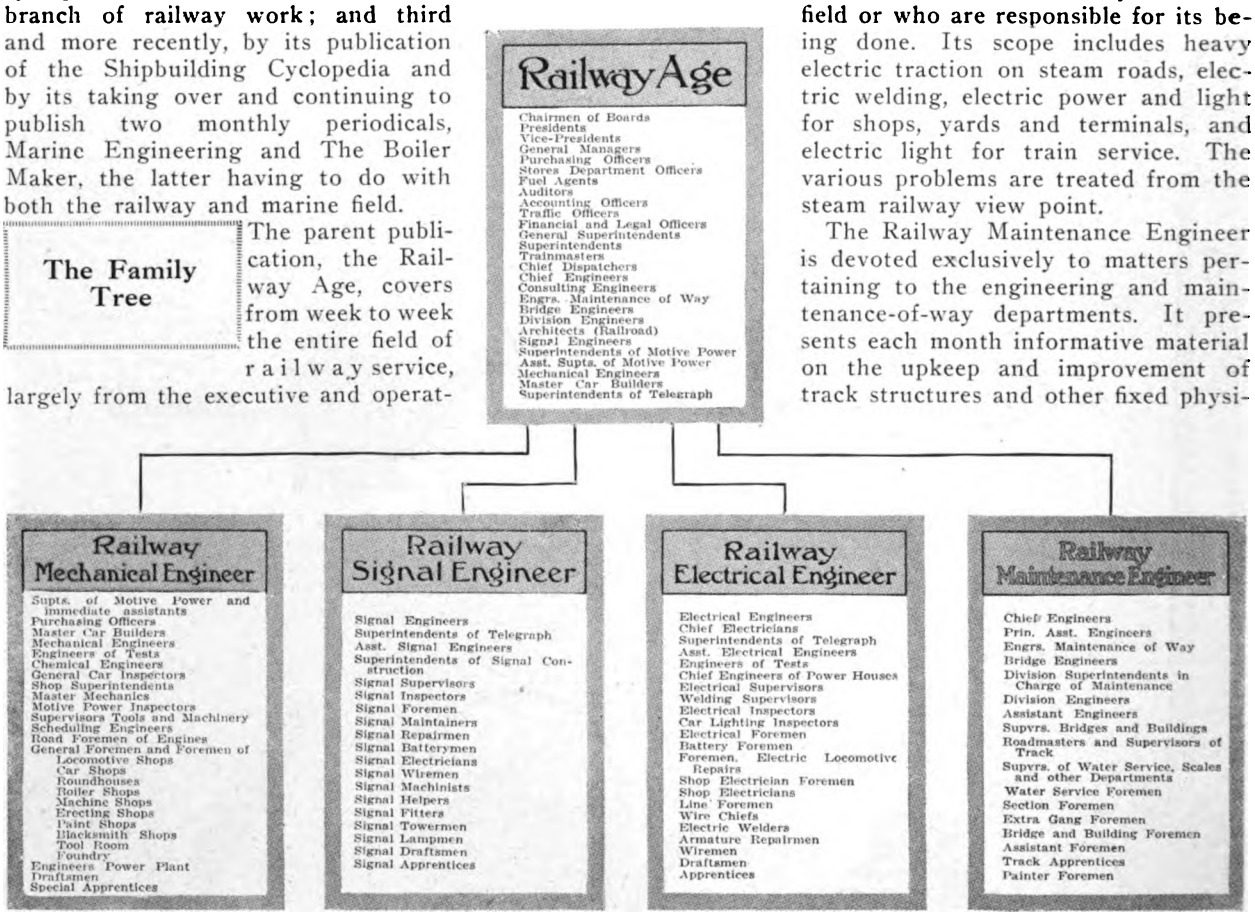
General

The Simmons-Boardman Publishing Company has established itself as "The House of Transportation," first, by its publication of the five leading periodicals devoted to railway interests, constituting the "Railway Service Unit"; second, by its publication from time to time of cyclopedias, each devoted to some branch of railway work; and third and more recently, by its publication of the Shipbuilding Cyclopedia and by its taking over and continuing to publish two monthly periodicals, Marine Engineering and The Boiler Maker, the latter having to do with both the railway and marine field.

The Family Tree

The parent publication, the Railway Age, covers from week to week the entire field of railway service, largely from the executive and operating standpoint, and has been doing this for sixty-six years. Executive officers find in it that information which they need regarding matters of operation, relations between carriers and public, finance and accounting, traffic, engineering and maintenance, locomotives and rolling stock, signaling, foreign railways, and all those subjects which are of most importance to them in their executive positions. It is primarily the executive's paper and a part of the working and educational equipment of those fitting themselves for executive positions.



The Railway Service Unit

The Railway Mechanical Engineer has specialized in railway mechanical problems and its life has been but little short of that period within which railways operated by steam have existed. It is devoted to motive power, railway shop equipment, and the problems of the maintenance and operation of each.

The Railway Signal Engineer, as its name implies, is designed specially for the use of those railway officers and employees who are required to have up-to-date knowledge of how signal apparatus is made, erected, operated and maintained. Though in some respects of a highly technical character, it nevertheless deals fully with the practical features of signal operation and maintenance.

The function of the Railway Electrical Engineer is that of meeting the needs of those who are doing work in the steam railway electrical field or who are responsible for its being done. Its scope includes heavy electric traction on steam roads, electric welding, electric power and light for shops, yards and terminals, and electric light for train service. The various problems are treated from the steam railway view point.

The Railway Maintenance Engineer is devoted exclusively to matters pertaining to the engineering and maintenance-of-way departments. It presents each month informative material on the upkeep and improvement of track structures and other fixed physical properties of railways.

For the assembling for convenient use and the permanent preservation of the material developed by the weekly or monthly issues of these several publications, the Simmons-Boardman Company has for many years published the Car Builders' Dictionary and Cyclopedia, and the Locomotive Dictionary and Cyclopedia. More recently it has added the Shipbuilding Cyclopedia for that branch of transportation service and acquired the marine publications previously mentioned. It is now rounding out the service of "The House of Transportation" by the publication of the "Material Handling Cyclopedia" and the present volume, the "Maintenance of Way Cyclopedia."

Related members of The Simmons-Boardman Family include books on transportation subjects for the seeker after a broad, practical knowledge of railway affairs or detail data on technical features of this industry. A Book Department is maintained, of which the scope is indicated by its slogan, "If it is on Transportation we can supply it."

SIMMONS-BOARDMAN PUBLISHING COMPANY, NEW YORK, N. Y.

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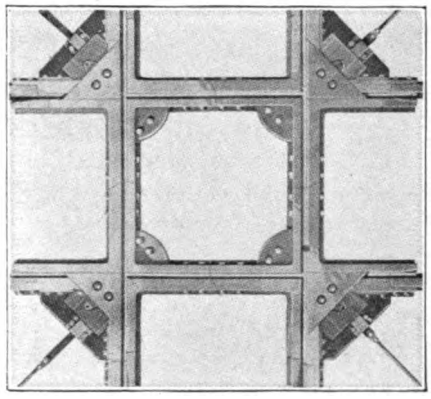
CONTINUOUS RAIL CROSSING

General

The soundness of the principle of the movable triangular block, as embodied in the Eymon crossing, and the practical advantages of this type of crossing in providing a continuous rail for the passage of traffic over steam road intersections, have been proved by the experience on one road dating from May 25, 1914, and on others for nearly as long a period. The saving in cost of maintaining the roadbed at the crossing, the multiplied life obtained for the crossing structure itself and the avoidance of the injurious effects of an open flangeway upon the equipment, have been demonstrated at each of the installations of this type of crossing.

The earlier types of Eymon Continuous Rail Crossings provided for double bolt locks connected to detector bars, which indicated positively the completion of the movement of the blocks. Standard lock pins were used, having a single hole for each pin. A single lever in the tower was used to throw the crossing, but when a lever was not available, the operating bars were connected to the appropriate derails. Later on, as the holes in the blocks were found to cause hair cracks in the adjacent manganese metal, they were placed below the block through a dependent lug specially provided for the purposes.



Solid Cast Manganese Eymon 4-Piece Crossing

As the bolt lock and detector bar are giving way to more modern types of locking, the general scheme for the interlocking of the four units of the Eymon crossing is now in process of development by the company with the active co-operation of the signal engineers of the roads which have been using this type of crossing. The aim is to adapt the crossing to operation from standard types of interlocking machines, with indicating contact points functioning with all the signals which govern at the crossing.

The Eymon Continuous Crossing

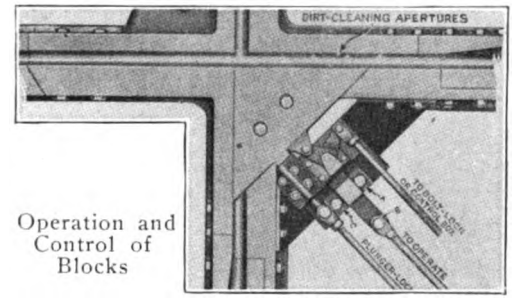
The principal feature of the Eymon crossing is the four triangular movable blocks made of manganese steel which, in the solid cast manganese Eymon 4-piece crossing, move on a solid bed of manganese steel, unaffected by contraction or expansion because of its being entirely within the structure. The four blocks are designed to fit into the exterior angles of the four corners of the crossing and are so arranged by means of an easy double bend in the operating bar that, as it passes through the slot provided in the blocks, it serves to shift them sidewise in a direction at right angles with a line bisecting the angle of the block where it touches the crossing intersection.

The blocks are approximately 28 in. long, measured along the sides which form the respective gage lines, and are generally 2 in. thick, but for the heaviest rail sections may be made as thick as 2¼ in. The operating bars, whose functions are to move, guide and make interchangeable the movable blocks, are 3¾ in. wide, 1 in. thick and about 4 ft. long. A feature of the crossing is the slotted apertures through the guard rail, which allow gravel, dirt, snow, etc., to be swept through instead of accumulating in the flangeways, providing a self-cleaning feature.

Features of The Eymon Crossing

The Eymon crossing may be installed as a unit in the same manner as any ordinary type of crossing, thus introducing no additional delays to traffic. No special foundation is required for the solid cast manganese crossing, but it can be installed on the ordinary timber or cross-tie foundation. All moving exposed parts have been eliminated from between the rails, avoiding the possibility of their being caught by dragging parts of cars.

The details of the crossings do not involve the use of special parts, but all are standard and interchangeable. The triangular movable blocks may be removed for inspection merely by removing two bolts. The absence of holes for the plunger lock pin within the block proper and the attachment of the slotted lug below the blocks, avoid reduction in the movable block section.



Operation and Control of Blocks

Service of The Eymon Crossing

By the closing of the opening across the intersecting flangeway through the Eymon principle, the impacts of the traffic are modified so that three-fourths of the destructive affects at the crossing are removed. The Eymon crossing will give service for as long a time as required for the traffic to wear down the solid manganese steel rail. The original crossings have in some cases already attained the length of service of three open flangeway crossings.

The reduced maintenance at the Eymon crossing comprehends a saving in the reballasting, the surfacing, the renewals of bolts and the routine operation of tightening bolts, as well as the expense of the crossing renewal. By providing a smooth continuous rail, additional safety is afforded the movement of traffic and a large element in the deterioration of rolling stock removed.

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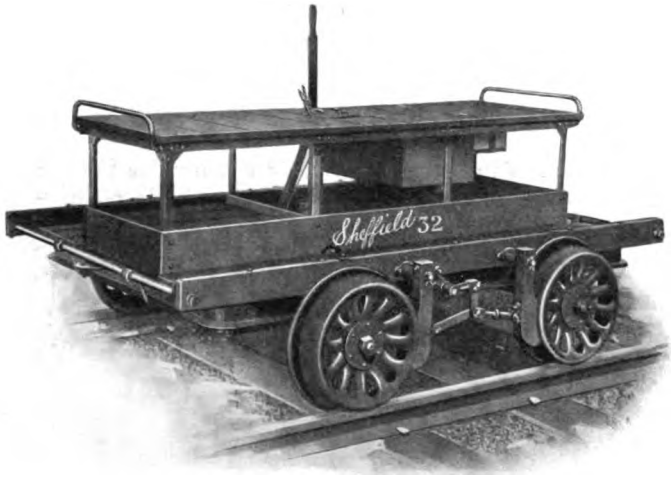
General

Fairbanks-Morse railway equipment includes railway motor cars, hand, velocipede and push cars; standpipes; coaling stations; tanks; towers; hoists; air compressors; "Y" oil engines from 10 h. p. to 200 h. p., "Z" engines from 1½ h. p. to 20 h. p.; Fairbanks scales, all kinds; electric motors, dynamos and alternators; lighting plants; starters; and pumps, steam, power and centrifugal, for every service.

No. 32 Section Car

The Fairbanks-Morse Sheffield "32" is built to supply the need for a powerful, simple, economical and dependable general service section car.

The "32" has a horizontal, kerosene or gasoline, two-cylinder, two-cycle, air-cooled engine which drives the wheels direct



Sheffield "32" Motor Car

through the rear axle acting as crank shaft. The engine is supported from a separate steel frame, giving a power plant independent of the rest of the car and easily removable. Air-cooling eliminates pump and connections—gives an engine of light weight—does away with water troubles due to freezing. The best material obtainable, combined with skilled workmanship and correct design gives a dependable, economical engine that will give satisfactory and continuous service.

All axles turn in Hyatt roller bearings $1\frac{7}{16}$" in diameter by 4" long with $\frac{9}{16}$" rollers—large and strong—reduce friction and make car easy running.

Spark and throttle are controlled by convenient levers on the seat right in front of operator. Two ignition switches are also placed here—one for each cylinder. Powerful brakes on all four wheels—operated by hand lever on side of seat.

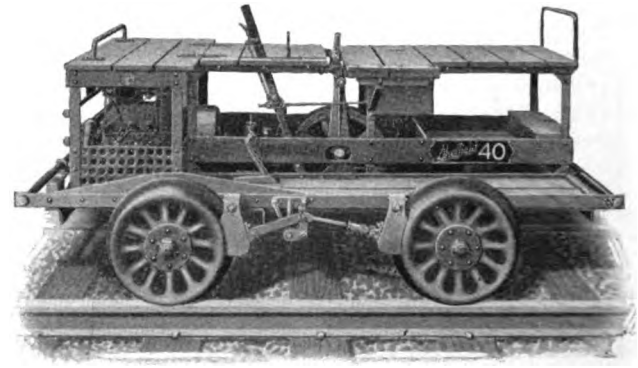
Frame is all steel securely riveted—all steel wheels, 16 in. in diameter, M. C. B. flange with forged hub plate. Strong, true running. Weight, 935 lb.

No. 40 Heavy Duty Bridge Gang

The Sheffield "40" meets the demand for a big, powerful car that will carry a bridge or construction crew with materials and a trailer as well.

The husky valve-in-head, two cylinder opposed, four cycle, air-cooled engine gives high turning effort at low speed. Affords ample reserve power for heavy grades. Air cooling eliminates pump and connections — means no cold weather troubles.

Friction transmission drives rear axle of car through roller chain and sprockets—gives free running engine—easy to start. Friction wheel is so arranged that the pulling power of the engine can be utilized in proportion to the load. This is accom-



Sheffield "40" Motor Car

plished by simply moving a lever convenient to operator. Friction disc is mounted independent of the engine so that there can be no thrust or strain on power unit.

All axles are provided with Hyatt roller bearings.

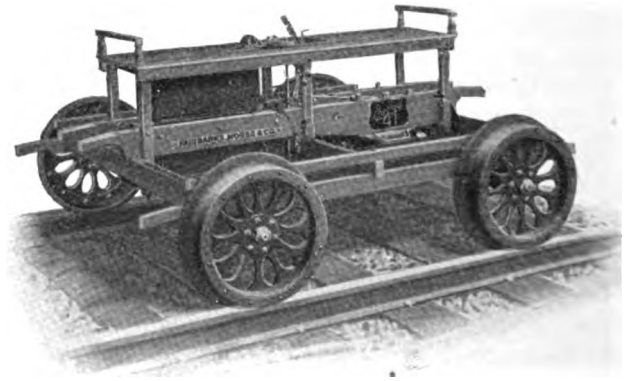
Lubrication is force feed—oil being supplied to bearings under pressure by a positively driven gear pump.

Control is easy and simple, levers, switches, etc., being within easy reach of operator. Strong steel frame—ample body room for men and tools—front part of seat can be raised, rendering power plant readily accessible. Pressed steel wheels, with forged hub plate—put on with taper fit—can't wobble or loosen.

No. 41 Center Load Inspection Car

The Sheffield "41" is a light, safe and economical car for use by maintainers and supervisors. This car has a 2-cylinder, 2-cycle, air-cooled engine which uses either kerosene or gasoline. No valves, carburetors, cams, or other trouble-giving parts.

Lubricating oil is mixed with the fuel before filling tanks and is taken from tanks by means of a fuel injection device into the crank case, giving am-



Sheffield "41" Motor Car

ple positive lubrication to piston, cylinder and connecting rod bearings. Lubrication is furnished in

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proportion to the work being performed, increasing when load is heavy and decreasing when running under light load. Starts automatically when car starts and stops when car stops.

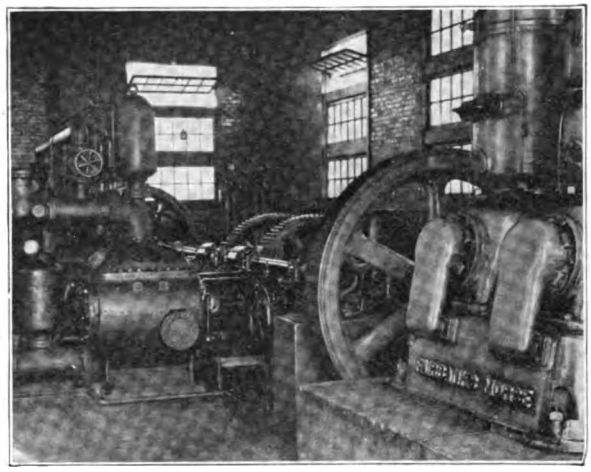
An automatic primer makes starting easy—no time wasted. Frame is wood reinforced with steel. Engine is supported on separate sills independent of main frame. No strain on the driving axle. Wheels are wood center, steel tread, M. C. B. flange, put on with taper fit.

Control from deck convenient to operator—powerful brake operated by hand lever on side of driver's seat. Every Sheffield motor car is thoroughly worked in on a circular test track for final tests and adjustments.

Water Station Equipment

Hundreds of pumping stations on all of the important railroads demonstrate the quality of Fairbanks-Morse equipment for this service.

Complete equipment made in the Fairbanks-Morse factories, insures an installation backed by an undivided responsibility and proven quality.



Pumping Station at Greensboro, N. C.

"Y" Oil Engines

"Y" engine performance records have established their dependability and economy. They use a wide variety of low priced fuel oils and operate on the moderately high pressure principle.

There are no igniters, timers, carburetors, spark plugs, magnetos, or switches. A simple starting device enables the engine to pick up full load in from five to ten minutes and run continuously over long periods with little attention. A licensed engineer is not required.

No water is used in cylinders—fuel is injected into combustion chamber and never comes in contact with lubricating oil. Main bearings are ring oiling and piston, piston pin and crank pin are lubricated from a force feed pump.

"Y" oil engines are adapted for either belt drive or direct connection to alternators. Sizes from 10 H. P. to 200 H. P.

General Service Steam Pumps

Fairbanks-Morse manufacture a great variety of pumps adapted to all conditions of service. The pumps most generally used for railroad water stations, where the discharge pressure does not exceed 150 lb. to the square inch, are the duplex piston pattern with capacity of 11 to 650 gal. per min., the duplex plunger and ring pattern with capacity of 235 to 2088 gal. per min., the duplex piston pattern with belt drive with capacity 13 to 1600 gal. per min., and the duplex plunger pattern with capacity 195 to 1600 gal. per min.

Pumping Station at Galion, Ohio

In the pumps of the duplex plunger pattern there are two general designs, one with a solid plunger which works, through a long metallic liner accurately bored to fit the plunger, and the other having a piston packed with square packing for use where the liquid pumped is gritty. In the duplex plunger pattern pumps for belt drive the suction valves are placed in a deck below the piston and the discharge valves in a deck above producing direct passages for the water through the pump which, together with the large proportionate area of the valves, permits operation at maximum speed without shock, vibration or strain.

Center-packed plunger pattern duplex pumps for belt drive are built for a variety of uses where the pressure to be pumped against is up to 250 lb., as in situations where a long pipe line is necessary or where there is a high vertical head to be pumped against. Capacities of these pumps are from 10 to 1600 gal. per min.

Centrifugal Pumps

The Fairbanks-Morse line of centrifugal pumps embraces a great variety of styles, with capacities ranging from 25 to 9,500 gal. per minute. The list includes single-stage, side suction pumps for heads up to 75 ft.; double-suction horizontally-split casing pumps for heads up to 150 ft.; multi-stage, split-casing, centrifugal pumps for heads up to 500 ft., and a complete line of single-stage vertical pumps for heads up to 75 ft.

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Coaling Stations

The problem which confronts the operating officer in contracting for new coaling stations is primarily one of cost: First, the cost to operate; second, the cost to maintain; and third, the cost of the finished plant. Wide experience gained in this work has enabled the engineers of Fairbanks, Morse & Co. to supply reliable and unprejudiced recommendations. This company takes the entire responsibility into its own hands, designs and builds a plant with its own forces, and manufactures the entire equipment at its factories. A single identity is thus carried throughout the work.

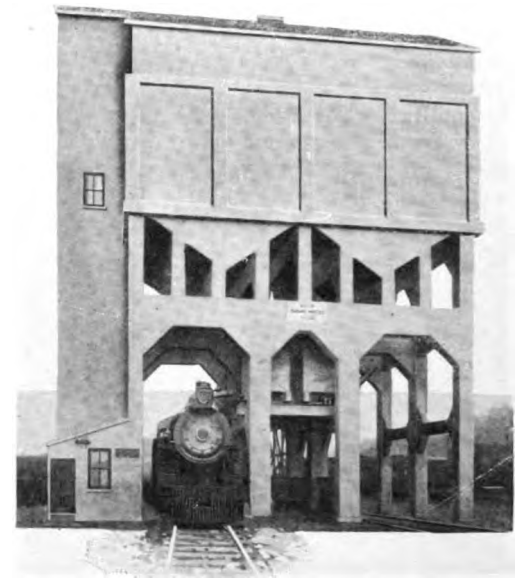
One of the principal advantages claimed for the Fairbanks-Morse type of coaling stations is simplicity of design and construction, resulting in reliability and small expense of operation. A coaling station must be in service all the time in order to fulfill its purpose of avoiding the need of running locomotives for considerable distance to take coal or an alternative resort to hand shoveling.

Coaling Station at St. George, N. Y.

There are a large number of conditions to be considered in the design and construction of such plants, some of which are included in the following:

1. Capacity of plant. 2. Kinds of coal handled. 3. Daily consumption. 4. Type of cars used (gondola, box, or self-clearing). 5. Length of receiving hopper. 6. Number of tracks served. 7. Whether or not weighing apparatus is to be considered. 8. Track clearances. 9. Whether or not coal is to be crushed or broken. 10. Kind of power required or available. 11. Whether or not coal is mixed. 12. Kind of construction (whether frame, steel or reinforced concrete). 13. Whether or not ground storage is to be considered. 14. Whether or not sand storage and drying are to be considered. 15. Whether or not cinder plants and pits are to be considered. 16. Fire regulation and protection. 17. Whether a terminal or isolated plant. 18. Location. 19. Release of cars. 20. Switching.

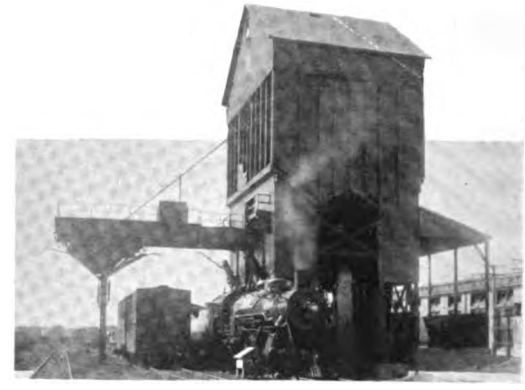
It is clear that engineering experience in meeting similar conditions is of the utmost value. Under the Fairbanks-Morse plan each plant is made a study in itself and is given careful individual design in order that it may adequately meet the particular conditions under which it is to be operated. Fairbanks-Morse coaling stations have been in use for many years



Coaling Station at Asheville, N. C.

and the success of these installations is attested by the number of "repeat" orders received from roads upon which these plants have once been installed.

During the past 17 years Fairbanks, Morse & Co. have erected approximately 440 coaling stations on 100 railroads in the United States. Some of the roads for which stations have been built in considerable numbers are the Atchison, Topeka & Santa Fe, 38; Baltimore & Ohio, 21; Seaboard Air Line, 20; Southern, 17. An illustration shows a coaling station built for the Santa Fe at Albuquerque, N. M. It is of 800 tons capacity and has coal and sand facilities on four tracks. The Fairbanks-Morse system of sand handling, drying and storage is operated in conjunction with this station. Other illustrations show the coaling station built for the Southern at Asheville, N. C., of 1,000 tons capacity, which is of reinforced concrete; and one for the Staten Island at St. George, N. Y., of 200 tons capacity, which was designed to meet special architectural requirements.



Coaling Station at Albuquerque, N. M.

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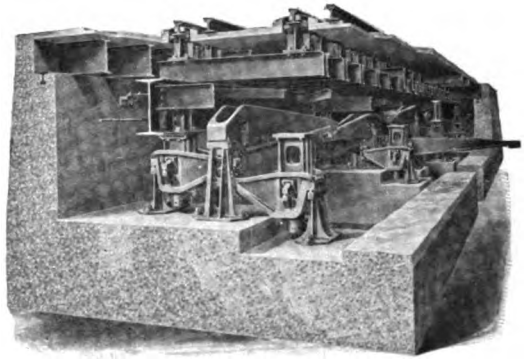
Scales

Fairbanks Scales are in general use on the railroads and include: track scales; wagon and stock scales; depot scales; portable platform scales; and hopper scales, for weighing grain in bulk. Fairbanks Scales are designed to meet all demands of service, and their reliability is backed by a long record of successful and dependable performance. They have been developed so as to embody the best ideas suggested by study and experience extending over many years.

Type "S" Track Scales

The Type "S" Suspended Platform Track Scale embodies all the latest refinements in scale design. It is stronger, more accurate, more finely sensitive and more permanent than the style of track scales of older design.

It has always been assumed in designing scale levers that the load is applied at the center of each bearing and is transmitted along the center line of each connected lever.



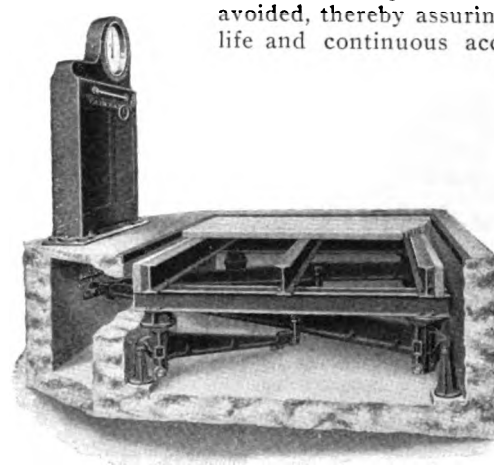
Type "S" Track Scale

The connections between levers of I-section must be made between pivots projecting from both sides of the levers. If the load upon both sides is not equal, or if there is the least warp or horizontal deflection in the lever, a torsional strain is introduced which levers of I-section are not shaped to resist. Loads applied to a track scale in ordinary car weighing are frequently greater on one side or on one end of the scale than on the other, with the consequence that pivots are unevenly loaded and torsional stresses set up in the levers.

In this track scale the initial load is suspended from the center of the main lever bearing and from that point is transmitted through the center line of the lever to the center of each succeeding bearing. The tip of one main lever of each pair is directly above or below the tip of the opposite lever, so that the combined pull of both levers is in one straight line to the center of the bearing, which is on the center line of the longitudinal lever. The same holds true at the connection of the longitudinal levers with the transverse lever. This construction eliminates torsional strain on the levers as well as the tendency to displace the levers from their bearings, and also prevents unequal wear upon the different parts of the same bearing. The double web lever is exceptionally well adapted to track scale use, having maximum rigidity with a minimum of weight.

Depot Scale with Dial

This scale is also built on the suspended platform principle which assures that the platform returns by gravity to its free weighing position, after displacement by load. Scraping of the bearings across the pivots is thus avoided, thereby assuring long life and continuous accuracy.



Depot Scale with Dial

It may be equipped with full capacity dial as shown, or with a single, double or full capacity beam.

Portable Platform Scale

Portable Platform Scale

The scale illustrated is an efficient portable platform scale designed on the suspended lever principle, by which fine sensibility and permanent accuracy are assured. By means of a drop lever the mechanism is freed from the jar and shock in loading or unloading the platform. This scale is furnished with arrow tip, single, double, or full capacity beam.

Hopper Scales

As in all the other modifications of Fairbanks Scales, the hopper scales embody all the latest features of scale design. The capacities vary in size from 2 bu. to 2000 bu. at a single draft.

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General

The Fairmont Gas Engine & Railway Motor Car Company, formerly the Fairmont Machine Company, is located at Fairmont, Minn., where it maintains a plant devoted to the manufacture of hand cars and hand car engines for every track service. Its models embrace 157 types of engines and motor cars, including special mower cars and disc weeding machines, although it is best known by its production of the Fairmont 4- and

Fairmont Plant

6-hp. motor car outfits, by which a hand car may be converted into a motor car.

The Fairmont motor car has been in practical use on the railroads for 10 years, and has been adopted as standard equipment by many of the largest railway systems. Over 18,000 Fairmont engines are in use today on more than 750 railroads, while 440 6-hp. motor cars were supplied the U. S. Government for overseas service. The company employs no sales agents, but deals directly with the purchaser, whether it be a railroad or an employee, through its main office. The success of the Fairmont plan is based upon the power, dependability, simplicity, and low repair and operating cost of its product.

Fairmont Motor Car Engines

Whenever it is desired to convert a hand car into a motor car, consideration will be given to the merits of the Fairmont engine. The original base belt tightener affords an efficient and economical car drive, due to its close adjustment, avoiding excessive belt tension and wear. A complete hand car outfit is shown in the illustration. The 4-hp. unit weighs 185 lb., the 6-hp. unit 260 lb.

The Fairmont engine in its present form combines all the time-proven features of previous models with thoroughly tested new features. The new Fairmont has a plain cylinder head without any valves in the explosion chamber and it will not lose efficiency or need repairs because of burnt, leaky or broken valves, or a timinig mechanism out of adjustment through wear. Experiments have proved that this cylinder head is of the most efficient shape for smooth throttling, and it is easily removable if removal of the carbon should ever become necessary. The Fairmont engine is a two-cycle engine only in the sense that there is a power impulse at every turn of the fly wheel. The many improvements, peculiar to the Fairmont engine, place it in a class by itself. Its smooth torque greatly reduces vibration and wear on the bearings.

The aluminum carburetor is a recent improvement in Fairmont engines which adds to their power, fuel economy and flexibility. The use of this type of carburetor saves 4 lb. of weight. The increase in fuel economy is shown by known records of 63 miles per gallon of gasoline with stops. The carburetor is built as nearly wear-proof as possible, and will last several times longer than previous types. This carburetor will also vaporize the present low grades of gasoline better than has been possible heretofore.

Operation of the Fairmont engine is facilitated by a priming cup for quick starting in cold weather and by long substantial spark and throttle levers, which are easily adjusted, even when the hands are covered. In point of fact, zero weather does not impair Fairmont service. The new closed-top non-spattering water jacket maintains the exceptional pulling power and load capacity which are characteristic of Fairmont engines. Smoothness with which the Fairmont engine delivers power at all speeds makes the car a comfortable one to ride on. Having two perfectly balanced fly wheels, the car retains its smooth running throughout its entire life. Being water cooled, the engine is especially efficient when pulling heavy loads at moderate speed, which is a common need in section service.

Fairmont Hand Car Outfit

The Fairmont throttles smoothly to any speed, even a walk, enabling the operator to comply with regulations for reduced speed. It reverses instantly and runs either way without turning the car. Every Fairmont engine is cranked like an automobile, which does away with the tiresome and dangerous practice of pushing the car to start the engine. The new starting crank works either way and is detached automatically by the starting of the engine. Experience shows that the 6-hp. engines are the better selection for medium and heavy sections, while the 4-hp. engine is preferable for light sections and for inspection service.

Fairmont Ball Bearing Advantages

A notable feature of the new Fairmont engine is the installation of ball bearings on the crankshaft, which is designed to make the engine last for an indefinite period, with repairs postponed for many years, and then only in such minor items as the renewal of piston rings. These S. K. F. ball bearings are self-aligning and therefore indestructible. Deflections due to the live nature of the crankshaft cannot wedge or strain the balls, for they are free to roll sideways as well as straight

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ahead. The bearings are in two rows which are staggered, thereby placing the load on a larger number of balls and lightening the pressure on each. The efficiency of these ball bearings is generally recognized by designers of railway equipment.

The ball bearings are made of crucible steel scientifically hardened and ground. They pass numerous inspections and tests, those being rejected which show even the slightest defect. The ball retainers are made in a single piece of special Swedish Lancashire iron, so that there are no rivets, screws, wires or other parts to work loose and cause failure. The use of S. K. F. ball bearings assure freedom from the periodical laying up of the cars for repairs. This provision abolishes the one weak feature of the 2-cycle engine, viz., loss of crankcase compression and the resultant power, whenever the babbit or bronze crank bearings wear loose. In tests equivalent to a normal service of several years these S. K. F. double-row self-aligning ball bearings, and the patented Fairmont self-adjusting packing, have proved wear-proof and gas-tight without attention. There are no oil or grease cups to be forgottten, for oil is mixed with the gasoline and used in exact proportion to the work done. The ball bearings thus insure full power and efficient operation for years without repair.

Fairmont Crankshaft

Aluminum Carburetor

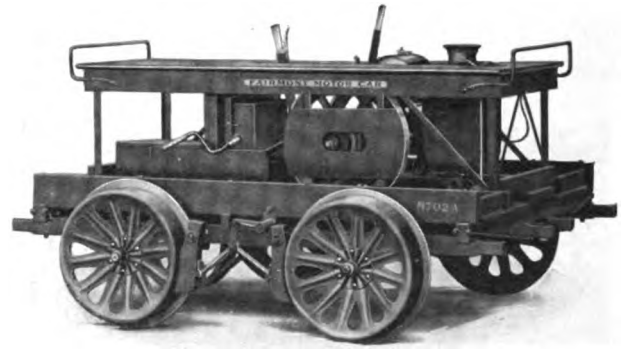
Ball Bearings

Other special features which have contributed to the popularity of the Fairmont engine are: Easy starting; great power with light weight; smoothness at all speeds; a minimum gasoline consumption; few working parts, and the company's guarantee of service, every Fairmont engine going out with the company's positive guarantee against defects of material or workmanship for three years.

Fairmont Section Cars

The utility of motor cars in saving both time and fatigue in maintenance work is generally recognized. Fairmont motor cars are built and equipped to fulfil this object efficiently. Every Fairmont car is equipped with Hyatt roller bearings. The wheels are pressed steel, with M. C. B. flanges and taper-bored malleable hubs. A lever brake presses wood shoes on all wheels.

The entire top of the housing is detachable from the six well-braced angle iron posts which hold it in place. The engine side guards also are removable. The frame is of ash and has four sills, six cross beams, two trusses and two drawbars. The 4-hp.



Fairmont Section Car

model, M601, weighs 850 lb. and the 6-hp. model, M602, weighs 900 lb. Wood frame section cars are more elastic and are thus less liable to be permanently distorted and made unsafe for operation by being twisted and strained when the wheels are caught in frogs or crossings.

Fairmont Bridge and Extra Gang Cars

In bridge and extra gang work, as well as on sections which occur in mountainous country, the service required of a motor car is frequently severe enough to demand a special type of car. The Fairmont cars for this use are specially geared to handle heavy loads or to negotiate steep grades. Simple Fairmont engines are thereby made to answer these purposes in place of the more costly multi - cylinder auto motors.

Fairmont Bridge Car

The two-speed transmission is rugged and strong enough for large overloads. Additional scope in speed and load capacity is secured simply by changing the size of the drive pulleys or sprockets. This type of car has a low first cost, dependable performance, simplicity of mechanism, which insures minimum repairs, and low fuel cost, which are characteristic of Fairmont cars.

Fairmont Power Decks

Many old hand cars are being effectively converted into motor cars by the addition of the Fairmont power decks with 4 or 6-hp. engines. The complete section car top costs but little more than the motor with a plank mounting. This deck is identical with the one furnished on the Fairmont section cars. The weight of the 4-hp. deck is 320 lb. and of the 6-hp. deck 420 lb.

The operation of changing to the improved type of car is exceedingly simple. The hand car is

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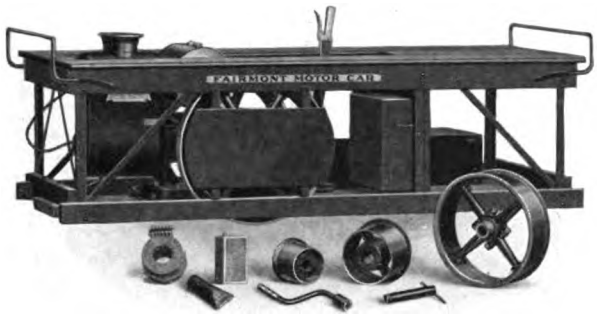
stripped of its gallows frame and gears; an opening is made for the insertion of the power deck, which is placed upon the car and bolted down; the steel split pulley is clamped to the drive axle and the belt fitted in place; the entire operation may be completed in less than two hours..

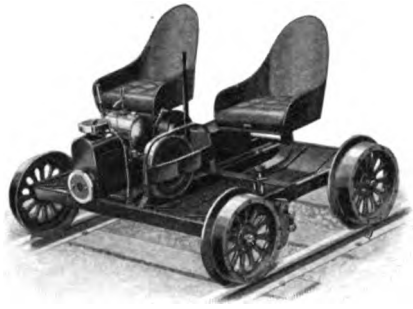
Equipment of cars with the Fairmont power deck conserves safety through the feature of easy stopping at all speeds. The sliding belt lever slacks the belt and instantly frees the engine, when the car may be quickly brought to a stop with the brakes.



Fairmont Power Deck

Fairmont Featherweight M 218

The need of a light car which may be used for the transportation of the railroad officer and a companion or attendant, or for a repairman traveling alone or with one other, is a live one in railroad operation. Safety and comfort are apparent in the design of the car shown in the illustration and these features have been appreciated by the many users of this Fairmont specialty.



Featherweight Car

The deeply cushioned spring-mounted auto seats absorb all vibration and jar from rough track. The car is reversible and will run equally well either way, so the seats also are made reversible. The steel frame is securely braced horizontally, but is flexible vertically, which assures that all wheels will stay on the rail when passing around curves.

The low center of gravity and control load distribution gives increased safety and this affords a sense of security when running at speed. The featherweight car is provided with the closed top water jacket and outlet pipe to prevent spattering of the occupants. An extension easy lift lever, by which the lifting weight in turning is reduced to 90 lb. can be furnished. The weight of the M 218 car is 590 lb.

Roadmaster's Inspection M 212

This Fairmont car has maintained its popularity since it was first introduced many years ago. The swivel office chairs face in any direction and the car is completely reversible, with ample power to overcome grades or wind pressure. This car is specially suited to track inspection, running evenly at all speeds from 3 miles per hour up, simply by moving the throttle. The engine is mounted over a loose wheel axle, making the other end easy to lift, and enabling the car to be turned in taking it from the track. The frame of the car is of standard car construction, with selected ash beams and sills, and the deck of the car is of elm. The wheels are 17 in. in diameter, wood filled, and with ¼-in. tires; the axles are 1¼ in. and have boxes equipped with Hyatt roller bearings. Wood shoes engage the four wheels. The weight of the car complete is 600 lb.

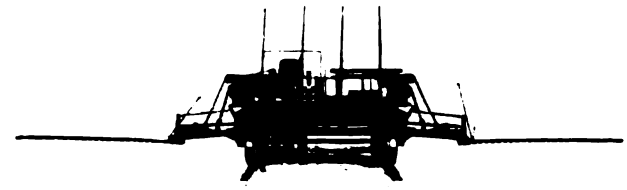
Roadmaster's Car

Railway Mowing Machines

The mowing of grass and weeds by motor car mowers has established its practical utility. A service of five years by many of these machines on some of the largest railway systems shows that the cost of operation, including labor, averages about $2 a mile, while hand cutting by men with scythes will cost from $5 to $10 a mile. This saving, applied to two divisions, would mean a saving of $1000 at a single cutting, which would involve about three weeks operation of the machine.

The Fairmont motor car mower cuts weeds and grass on both sides of the track at the same time and moves at a speed of from two to four miles an hour. The machine cutting supplies a smoother and better-appearing job than hand labor, besides releasing the section gangs for track work. This is especially important at this time when labor is scarce, the wages of labor high and the efficiency of labor low. A car will pay for itself in a single season.

The sickles and car are run by a standard Fairmont 6-hp. engine. While cutting vegetation the car progresses at a speed of 3 miles an hour. The machines have been improved each season with a view to increasing the durability of those parts which showed hardest wear. The use of a high grade of materials, with the five years of experience gained in this service, assures that the machines as now perfected will give results commensurate with the reputation of the other Fairmont products.



Fairmont Mower Car

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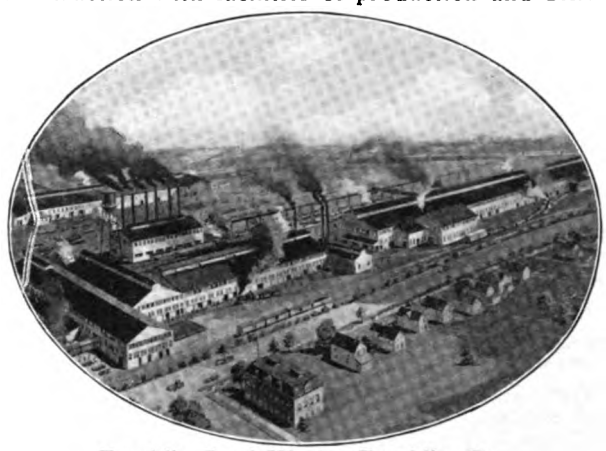
General

The Franklin Steel Works, Franklin, Pa., makes a specialty of manufacturing concrete reinforcing steel, two of its mills, with a combined capacity upwards of 250 tons per day, being devoted exclusively to the production of steel for this purpose. It is the aim of the company to combine a wide experience in reinforced concrete construction with facilities of production and delivery adapted to any kind of work. To this end the company maintains an engineering and estimating staff prepared to assist in design or to submit figures for steel required on contract, with bars cut to length, bent to specifications, and delivered ready for the forms. A large and complete stock of bars in the sizes and types manufactured is usually available for immediate shipment and facilities are maintained to handle all styles of bending, such as is required in members for beams, girders, floor slabs, stirrups, etc. Franklin Reinforcing Steel is used extensively by the leadings engineers and contractors of the country, including such organizations as the Pennsylvania, New York Central, Erie, D. L. & W., and other well known railroads; the Aberthaw Construction Co., Stone & Webster Engineering Corp., McClintic-Marshall Co., Hunkin-Conkey Construction Co., Thompson-Starrett Co., James L. Stuart Co., Concrete Steel Co., Trussed Concrete Steel Co., Corrugated Bar Co., Atlantic Refining Co., The Texas Co., General Electric Co., Swift & Co., American Locomotive Co., Pennsylvania State Highway Department, and the U. S. Government.



Franklin Steel Works, Franklin, Pa.

The Franklin Reinforcing

The Franklin Steel Works manufactures its reinforcing from railroad rails. The process of manufacture consists essentially of placing the entire rail first in a heating furnace and therein subjecting it to a long, slow, annealing heat. From the furnace it passes through an 18-in. slitting mill which separates it into three pieces or billets, one billet comprising the rail head, a second, the web, and the third, the rail base. On the theory that the more heating and rolling a steel gets the better it becomes, this heating and rolling involved in the manufacture of the reinforcing, although typical of reinforcing steel manufacture in general, is a point in favor of the Franklin product inasmuch as it is a process of reworking an already well-rolled product.

Additional points in support of the manufacture of reinforcing bars from railroad rails are based upon the quality of the raw material used. The stress which reinforcing steel is often called upon to withstand and the vital place it often occupies by virtue of its supposed strength make it of great importance in this as in other metal products that the material used should conform fully to expectations. While the character of any stock of steel can be closely determined by physical tests of representative samples, still it is obvious that the use of a uniformly high grade, rigidly inspected material in its manufacture is of tremendous value and warrants the placing of even greater reliance in the material, which can be utilized advantageously in reducing the customary factor of safety in construction.

It usually happens that railroad rails are more closely specified as to permissible variations in chemical or physical properties and are more thoroughly and severely tested for strength than other grades of new or old raw materials, which are economically available for use in the manufacture of reinforcing steel. The cost of a new reinforcing billet of a quality equal to that of the rail billet and subject to the same strict guarantee of uniformity at present prices is usually as large as those at which reinforcing bars are sold. It is claimed that this high grade quality of raw material together with the fact that only rails are used, afford a correspondingly high quality and uniformity of material in the Franklin bars.

The Franklin Company confines its activities to the production of plain round, plain square and square twisted bars, which are manufactured and sold under the specifications as drawn for this grade of steel by the American Society for Testing Materials, the Association of American Steel Manufacturers, and the Rail Steel Products Association. These specifications are as follows:

	Plain Round or Squares	Twisted Squares
Ultimate Tensile Strength in lbs. per sq. in., Min.	80,000 lbs.	80,000 lbs.
Yield Point in lbs. per sq. in., Min.	50,000 lbs.	50,000 lbs.
Elongation, per cent in 8-in. min.	1,200,000	1,000,000
	T. S.	T. S.
Cold Bend without fracture;		
Bars under ¾-in. in diam. or thickness	180 d 3 t.	180 d 4 t.
Bars ¾-in. or over in diam. or thickness	90 d 3 t.	90 d 4 t.

The company's standard reinforcing bars are made in the sizes and weights shown in the table, square twisted bars having the same weight and area as plain square bars:

TABLE OF WEIGHTS AND AREAS

Size	Weight lbs. per lin. foot		Area in square inches	
	Round	Square	Round	Square
¼ in.	0.167	0.212	0.0491	0.0625
5/16 in.	0.261	0.333	0.0767	0.0977
⅜ in.	0.375	0.478	0.1104	0.1408
7/16 in.	0.511	0.651	0.1503	0.1914
½ in.	0.667	0.850	0.1963	0.2500
9/16 in.	1.043	1.328	0.3068	0.3906
¾ in.	1.502	1.913	0.4418	0.5625
⅞ in.	2.044	2.603	0.6013	0.7656
1 in.	2.670	3.400	0.7854	1.0000
1⅛ in.	3.379	4.303	0.9940	1.2656
1¼ in.	4.173	5.312	1.2272	1.5625

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General

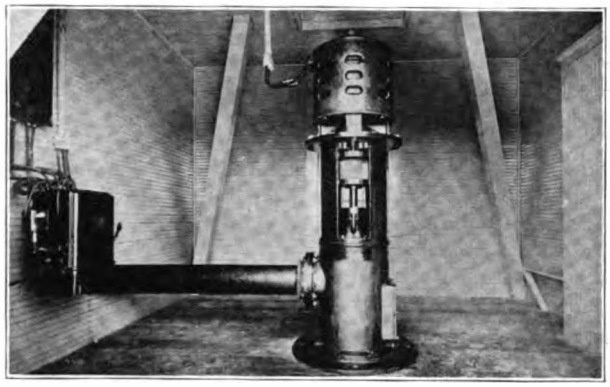
The General Electric Company has been for more than thirty years manufacturer of power plant and other electrical equipment, which is coming more and more into use on steam railroads.

G-E motors have been applied to pumping, coal handling, various uses in railroad shops, and to a growing extent for driving portable machines in the field. The G-E turbine headlight set, extensively used for headlights and other lights on steam locomotives, is also adaptable for illuminating night-work on jobs where steam is available.

This Company has taken also an active part in steam railroad electrification, two of its largest installations being the Chicago, Milwaukee & St. Paul, and the Butte, Anaconda & Pacific, and G-E electric locomotives are also familiar equipment on roads which have adopted electric propulsion locally.

Electric Pumping

With experience in applying electric drive to pumps in mining, chemical, and many other industries, as well as steam railways and power plants, this company is in a position to supply all electric equipment for railroad pumping stations where electrically driven pumps are coming into marked favor. Standard motors can be supplied either of the horizontal or vertical types. together with all of the necessary control accessories to make the installation entirely automatic if desired. Electric drive for this service is especially suited to locomotive watering stations, because the tank may be kept full, regardless of variations in the demand for water, without any attention other than periodical inspections.

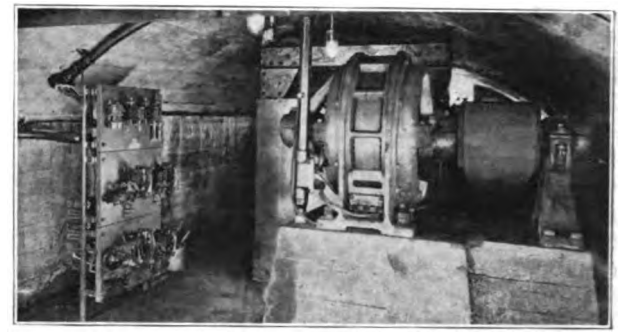


G-E Vertical Motor and Control—Pumping Station, Atchison, Topeka & Santa Fe

For heavy service requiring more than 75 h.p., the G-E box-frame induction motor for driving centrifugal pumps is used, especially in locations where moisture is often present. Necessary equipment can also be furnished for hand or automatic starting, together with float or pressure switch for water level control. (Bulletin 61301).

Electric Material Handling

The advantages proved for electric drive when applied to material handling machinery have extended its application to steam railroads for the operation of conveyors, hoists, cranes, car dumpers, etc., in coaling stations; to a limited extent to electric shovels, wrecking cranes and similar heavy equipment, as well as for the operation of hoisting machinery for handling material in warehouses, shops, etc. The use of electric motors for operating turntables is also very general.



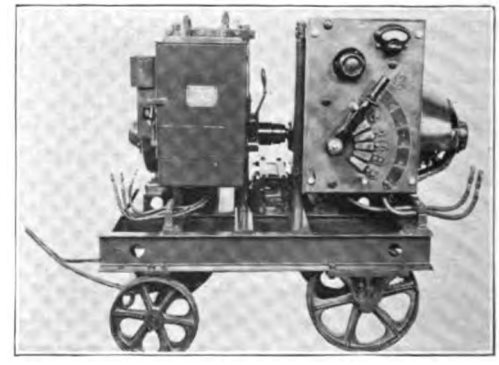
G-E Motor and Control—Coal Storage Plant, Erie Railroad

The General Electric Company is prepared to furnish the complete electrical equipment for work of this kind, including motors, alternating and direct current, some of which have been designed especially for such service; control equipment of various types, either automatic or non-automatic, for controlling the motor; and also electric brake, limit switches, and other special devices required to obtain the desired performance.

Electric Arc Welding

The use of welding by means of an electric arc has been developed so that it is now practical in nearly all operations where iron or steel are to be united or built up. Its principal advantage is economy due to transforming energy into heat in a small space and confining it to the immediate locality of the weld. It offers a means of repairing frogs and switches, either on the track or in maintenance repair shops.

G-E arc welding equipment meets practically all requirements. The Motor Generator Welding Sets are made either portable or stationary. The generator of the single-operator type may be driven by any standard form of power. It automatically reduces the open circuit or "striking" voltage to the proper value for welding when the arc is established. The generator of the constant potential type may also be driven by any standard form of power. Its characteristics permit one or more welding circuits to be operated simultaneously without interference with one another. Details may be obtained in Bulletin (48932A).



Portable, Single Operator Arc Welding Set, Motor Driven

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The Resistor Type of welding apparatus consists principally of a light weight portable resistor and is intended primarily for electric railway work where the more efficient welding generators are not desired.

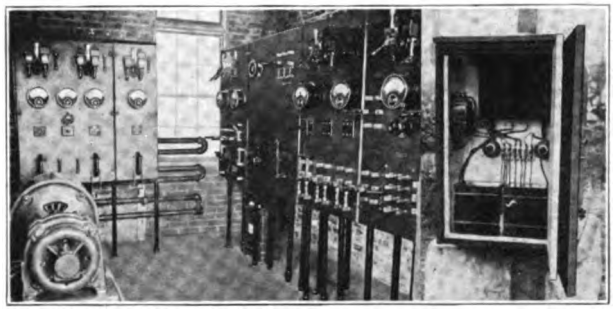
The Automatic G-E Arc Welder is a mechanical device to feed automatically a metallic electrode to the work. It takes power from any standard welding generator and is used as a machine tool for welding seams and building up flat and cylindrical surfaces. (Booklet B3575.)

Battery Charging Apparatus

G-E motor generator sets are in common use for signal battery charging. Being direct connected, they are very reliable and require minimum floor space. They are readily adapted for all of the current and voltage requirements for signal work. Switchboards and all accessories can be supplied with them for the proper control of power and charging circuits. The switchboard panel is mounted on the smaller sizes.

G-E current rectifiers are of either the mercury arc or the "Tungar" type. The former are made in 10, 30 and 50 ampere capacity.

The G-E "Tungar" rectifier is particularly convenient for charging batteries at outlying points near interlocking stations. It is simple, light in weight, self-starting and economical. It is furnished in four sizes.



Power Station, Electric Interlocking, New York Central R. R. "Tungar" Rectifier Installation, D. & H. R. R.

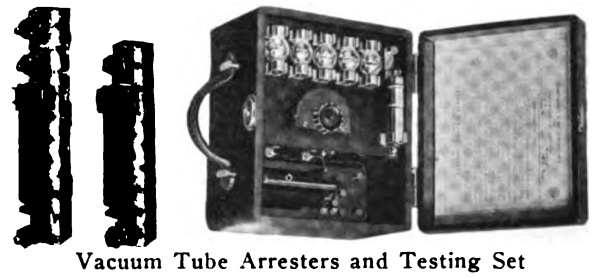
Automatic Signal Substations

By the use of G-E automatic substations, signal delays due to failure of power supply for alternating current systems can be practically eliminated. They require no attendance other than ordinary maintenance.

These stations make it possible to utilize power from more or less unreliable sources. A transmission line supplying automatic block signals or a local load may be supplied from either of two sources; on failure of the normal source, the emergency source is immediately connected and vice versa.

Lightning Arresters

The G-E vacuum tube arrester, for low voltage circuits, constructed on the principle of a large gap in a vacuum, meets the requirements of low sparking potential and, at the same time, avoids the danger of short circuits. It is made in two forms, one for use where it is desired to bring the wires in at the top and out at the bottom of the case, R. S. A. standard terminals are used throughout (Bulletin 45600A.)



Vacuum Tube Arresters and Testing Set

To obtain the highest degree of protection from vacuum tube arresters, tests should be made from time to time to determine the spark potential. Tests can easily be made on the ground by means of testing sets which can be furnished in two types for operation from dry batteries within the instrument or from the distribution circuit.

Multigap arresters, for high voltage power circuits, are of two types, the graded shunt resistance and the compression chamber type, either of which is suitable for indoor or outdoor installation. The arresters should be placed at the terminals of the transformers.

Testing Instruments

For testing railway signal apparatus, the Type S_2 portable volt-ammeter is small, compact and substantial. It is constructed on the D'Arsonval principle and arranged for measuring either current or potential. Contained in a mahogany case.

Resistors

G-E Enameled Resistor Units are especially desirable for installations which require small and mechanically strong resistors capable of withstanding extremes of temperature and adverse atmospheric conditions such as are encountered in railway signal service. Flexible leads minimize danger of broken connections, and binding posts conform with R.S.A. specifications, while the blue vitreous enamel fused to the wire-wound body insures protection from moist or oxidizing gases. (Bulletins 68947 and 68954A.)

Two of the Various Forms of G-E Resistor Units

Transformers

In G-E transformers reliability has always been the first consideration and the many thousands of kv-a. capacity now in service have proved their ability to operate continuously with minimum losses and maximum factor of safety. For power distribution service the Type H transformer is used, which is oil insulated, self-cooled and designed for pole mounting. Made from ½ to 200 kv-a. (Bulletin 45110A.)

For reducing the voltage still lower to a value suitable for operating signal lamps, the G-E Type M transformer is available. (Bulletin 45105.)

95-385

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General

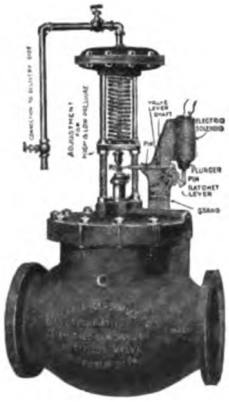
The Golden-Anderson Valve Specialty Company, of Pittsburgh, Pa., is a specialist in the manufacture of patent automatic steam and water service valves, of which the railroads are large users. Automatic control, when serviceable and reliable, is always profitable and many times imperative. It has been the aim of the Golden-Anderson Company to produce types that are both serviceable and reliable. The prevention of waste and water shortage, arising from inattention or defective equipment, and the improvement of water service in general, are problems, in the solution of which Golden-Anderson valves may be used with distinct advantages.

Valves for Water Service

Automatic control, air and water cushioning, and the absence of metal-to-metal seats are outstanding features of these valves. The automatic control simplifies the operation; the air and water cushioning prevents "hammer," and the absence of metal-to-metal seats prolongs the life of the equipment. The valves consist of a cast iron body, lined with bronze down to and including the valve seat, and of a main valve. The main valve is a bronze cylinder, closed at the bottom and fitted with renewable wear-and-tear parts. The main valve acts as a slide valve and is operated by water pressure, the valve being opened by pressure from below and closed by pressure from above. The air for cushioning is obtained through a vent in the valve body. All parts of the mechanism with which the valves are equipped, such as springs, diaphragms, floats, electrical attachments, etc., serve only to direct the water pressure properly, or to facilitate the operating of the valves by hand or from distant points. Obviously this equipment is different for different valves depending on the uses to which they are to be put.

Controlling Altitude Valve

The controlling attitude valve is adapted to stand pipes, reservoirs, and storage tanks. Advantages afforded by these valves are the prevention of overflowing of the tanks, no floats, valves, or fixtures inside of the tanks to become inoperative in freezing weather and no water hammer. The assurance of a constant supply is an additional advantage in gravity or automatic pumping systems. The valves can be controlled (1) automatically by water, (2) by electricity, or (3) by hand. They can also be arranged (1) to close automatically when ruptures occur in the mains, or (2) to "work both ways" on a single line of pipe used both for supply and discharge.

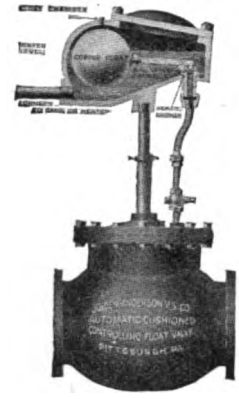


Altitude Valve with Solenoid

The float valve is adapted to interior tanks, particularly hot water wells. Its use insures a constant supply and eliminates the expense and nuisance of overflowing or running dry. The valve seats tightly and can be adjusted to operate at fast or slow speeds.

Float Valve

The controlling float valve is particularly well adapted to boiler feed water heaters where it affords an effective control of the admission of make-up water. The float chamber is located on a level with the desired water stage in the heater, the valve being located wherever convenient.



Controlling Float Valve

The float is located in a separate chamber, thus avoiding any annoyance from floats or fixtures inside of the heaters. The valves are built in ½-in. to 24-in. sizes and of the angle or globe patterns and will operate on ½-in. to ¾-in. variations.

The regulating valve is adapted to the service of maintaining without shock a constant pressure in terminal mains. These valves are suited to high or low pressures, and can be fitted with an electric attachment for opening or closing from distant points, thus assuring a full pressure in case of fire. The electric attachment consists of a solenoid cam and ratchet gear, and requires but a momentary current to set it in operation.

Regulating Valve

The electric water service valve is fitted with a handle, and stem for manual opening and closing, and is equipped with an electric attachment for operating from distant points. A valve of this kind is obviously a valuable article in cases where it is a matter of economy, and possibly of vital importance, to be able to operate remotely located valves by merely pressing an electric button in a central station.

Electric Water Service Valve

Details of the construction and operation of its valves can be secured from the Golden-Anderson Company, and they are also ready to assist prospective buyers in using valves to the best advantage.

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ZINC CHLORIDE WOOD PRESERVATIVE

Zinc Chloride for Wood Preserving

The Grasselli Chemical Co., Cleveland, O., is one of the largest American manufacturers of zinc chloride for use in the preservation of wood. This material is produced by a complicated chemical process during which zinc is derived from zinc ore, and finally converted into the chloride form by treatment with hydrochloric (muriatic) acid.

Texas Hewn Pine Ties Treated with Zinc Chloride
Forty Per Cent Still Sound After 14 Years' Service

Introduced in this country about 30 years ago as a tie preservative after extensive use in Europe, it has established itself as one of the principal wood-preservatives.

The merits of zinc chloride as a preservative of timber are indicated by the following extract from the proceedings of the American Railway Engineering Association taken from a report on the life to be obtained from zinc treated ties, following a recent study of track records and investigations: "Proper treatment will, at least, double the life of an untreated tie in the same situation. To illustrate: If a pine would give four years' life untreated, eight years could be figured upon when treated with zinc chloride, and the same result would apply to other woods."

Zinc Chloride Treatments

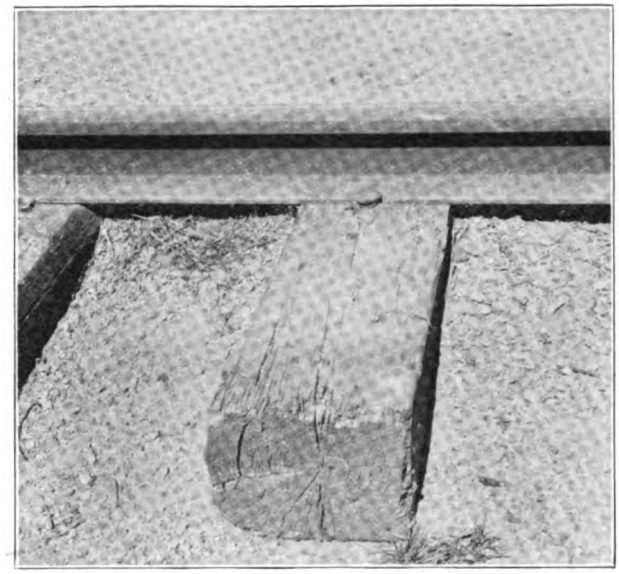
In practice zinc chloride is used alone and also in combination with creosote, the process best adapted to a particular work depending upon the climate, the kind of wood, the conditions of service under which the timber is to be used, etc. On this point the A. R. E. A. has expressed itself as follows: "That in localities where the rainfall is excessive and with a humid atmosphere, where zinc chloride treatment would be unfavorably influenced by leaching, and in dry climates where checking of the timber is likely to be excessive, or the mechanical abuse of the fiber is extreme ....., the introduction of some lubricating agent with the zinc chloride will have a beneficial effect ....."

The straight zinc treatment as prescribed by the A. R. E. A. and which constitutes the most largely used of the zinc processes, consists essentially of running seasoned wood in lots of uniform kind and size, into a cylinder, therein subjecting it first to a steaming treatment, then to a vacuum drying treatment, thereafter to a treatment of zinc chloride solution under pressure, and finally to a second vacuum drying treatment. It is required in this treatment that the material shall retain an average of 0.5 lb. of dry zinc chloride per cubic foot and that the chloride shall permeate all sapwood and as much of the heart wood as possible. The merits of this process are indicated by the fact that over 19,637,000 ties or over 50 per cent of all the ties treated during 1919 were treated by this process.

Of the several preservative processes in which zinc chloride is used in combination with other materials, the zinc-creosote emulsion process is practically the only one now in general use on railroads. In this process an emulsion of zinc and creosote is injected into the ties with a required absorption of 0.5 lb. of zinc chloride and 3 lb. of creosote per cu. ft. Over 2,950,000 ties were treated in this manner during 1919.

Grasselli Zinc Chloride

The Grasselli Chemical Company, the pioneer manufacturer of zinc chloride in this country, provides the chemical both in the fused and in the 50 per cent solution forms, the fused chloride being furnished in sheet steel drums holding about 1100 lb., and the solution, in sellers' tank cars of capacities up to 100,000 lb. The zinc chloride conforms fully to the A. R. E. A. specifications which require that "The zinc chloride used shall be acid free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent soluble zinc chloride and in any solution purchased, the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required."



Texas Hewn Pine Ties Treated with Zinc Chloride
100 to 900 per Mile Still in Track After 16 Years' Service

This chemical is manufactured and carried in stock for immediate shipment at Grasselli, Ind., about 25 miles from Chicago, and at Cleveland, O.

THE GRASSELLI CHEMICAL CO., CLEVELAND, O.

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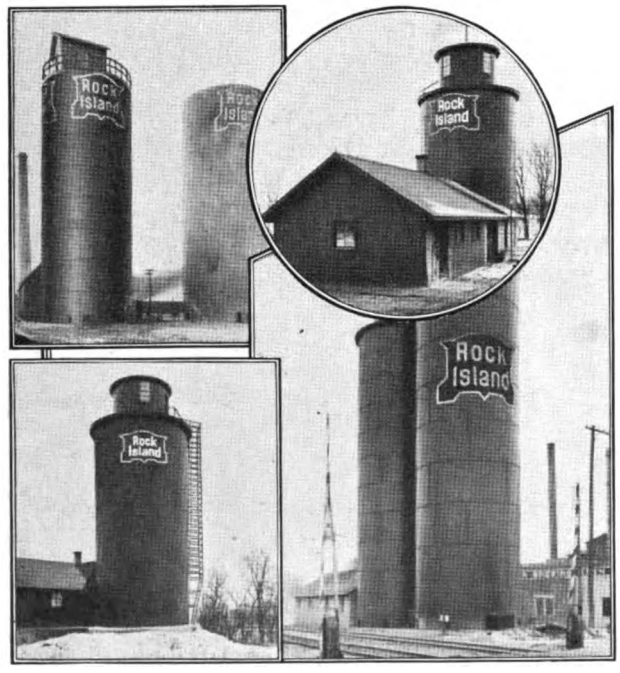
WATER TREATING PLANTS

General

The necessity of an adequate supply of water suitable for use in locomotive boilers is becoming more generally recognized and appreciated. Adequacy of supply is the first consideration, but as the cost of water has usually just begun with its delivery to the boiler, its actual cost is largely controlled by its suitability. The effects of bad water upon the capability of a locomotive to perform its required service and upon the cost of maintenance and repairs are almost immediately apparent. Continued use aggravates the condition, both as to capacity to handle tonnage and as to repair expense until the rebuilding of the boiler is the only recourse available. Congestion of traffic and frequent shopping are in many instances directly traceable to bad water. For this reason the treatment of such waters to render them fit becomes one of the important problems of railway operation. Its correct solution is of positive benefit since observation of the results obtained from treating plants demonstrates conclusively that there are few investments in connection with railroad property that will show appreciable returns in so short a time as the installation of properly designed and intelligently operated water-treating plants.

The problem is complicated by the fact that it is specific with reference to different roads and frequently with reference to different divisions of the same system. This requires that each source of supply be the subject of individual investigation.



Typical Graver Water Treating Plants

The interest of the maintenance-of-way department in the matter of water-softening arises from the fact that plants for the treatment of impure waters are, both as to maintenance and operation, largely under its care. It is obvious, then, that the services of experts in determining the nature of the treatment to be administered and prescribing the apparatus by which the treatment is to be carried out may be of the greatest value in insuring an understanding on the part of employees of the importance of the problem with which they are concerned and in emphasizing the necessity of accurately carrying out the treatment which has been prescribed.

Graver Service

The Graver Corporation, East Chicago, Indiana, formerly known as the William Graver Tank Works, not only manufacturers and installs water-treating plants, but, through its railroad department, makes exhaustive analyses of the condition of the water to be treated, the character of the reagents to be employed and the most effective method of their employment, and, what is frequently of as great importance from an operative and maintenance point of view, of the engineering considerations involved.

Graver Service, in brief, begins with filling your request for information; extends through the analysis and study of your water problem, with an authoritative solution thereof; provides for the proper installation of the correct apparatus; covers the starting of your equipment, with personal instructions to your employees put in charge; and continues throughout the full term of use of the apparatus.

The merits of the Graver type of water-softening plants have been proved by many years' service on a great number of roads. One of its chief features of interest from the maintenance viewpoint is the fact that its operation can in most cases be cared for by the expenditure of the time of one man for one or two hours per day, leaving the rest of the operator's time free for employment on other work. If the softener is installed in connection with a pumping plant or coaling station, no additional labor is required.

In this connection the results obtained for the B. & O. C. T., by the Graver Type "K" water softener at Harvey Junction, Ill., will prove interesting. A statement of this road on Feb. 18, 1918, shows that, as one economy effected by this softener, the number of boilermakers and boilermakers' helpers employed was reduced between 35 per cent and 40 per cent. At the then prevailing rate of wages this reduction amounted to over $10,000 per year, or more than the total cost of the water-softening plant. The percentage of reduction in the amount of boiler work under the several heads was as follows: arch bar tubes renewed, 54 per cent less; broken and leaky staybolts renewed, 70 per cent less; bursted or collapsed flues renewed, 70 per cent less; flues reset, 31 per cent less; and sets of flues expanded, 72 per cent less.

Another instance of a remarkable saving is recorded in the installation of a Graver Type "K" softener at North Little Rock, Ark., for the Missouri Pacific This softener was installed in 1917 at a cost of $15,000. During its three years of operation, this softener has removed over 1,500,000 pounds of incrusting solids from the feed water it has treated. Based on the conservative figure of 9½ cents per pound of scale removed, the consequent savings over the three-year period amount to approximately $145,000, or nine times the total investment.

The Graver Corporation not only makes every type and size of water-softener and filter, but in addition, is also an extensive manufacturer of steel

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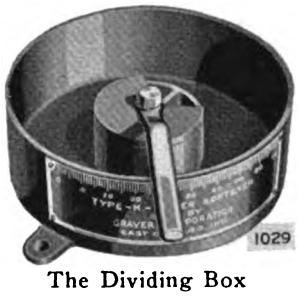
tanks for a great variety of railway and industrial purposes. The headquarters for its Railroad Department is maintained in the Steger Building, Chicago, where all communications from railroads are received, and where competent engineers give every water problem careful consideration from a practical as well as a scientific standpoint.

Type "K" Water Softener

Of the different types of softeners manufactured by the Graver Company, the Type "K" is the one best adapted to the treating of water for locomotive consumption. This is a continuous type system, ordinarily employing lime and soda ash reagents, and with the possible exception of a number of improvements and refinements characteristic of the more recent installations, is the type of Graver plant in extensive use on American and foreign railroads.

In this system the water enters the softener through an inlet pipe which originates at the flange in the shell of the cylindrical steel settling tank, and extends upward through the tank (a cold weather precaution) to a point above an enclosed water wheel; a valve actuated by a float in the settling tank being inserted in the line as a means of automatically starting and stopping the softening process (where such an arrangement is practicable). Discharging upon this wheel the raw water imparts to it the motion required to operate the agitator paddles in the down take (the cylindrical center tank). Thence it flows through a perforated stilling plate into a weir box, the weirs accurately dividing the stream into two proportionate parts, the larger passing directly into the downtake, the smaller, to a dividing box located at the top of the chemical feed control tank. Here a further division is made, one portion entering the control tank and the other being exhausted. The dividing box itself is adjustable, thereby embodying the very desirable feature of permitting the chemical treatment to be varied at any time to suit variations detected in the degree of hardness of the raw water.

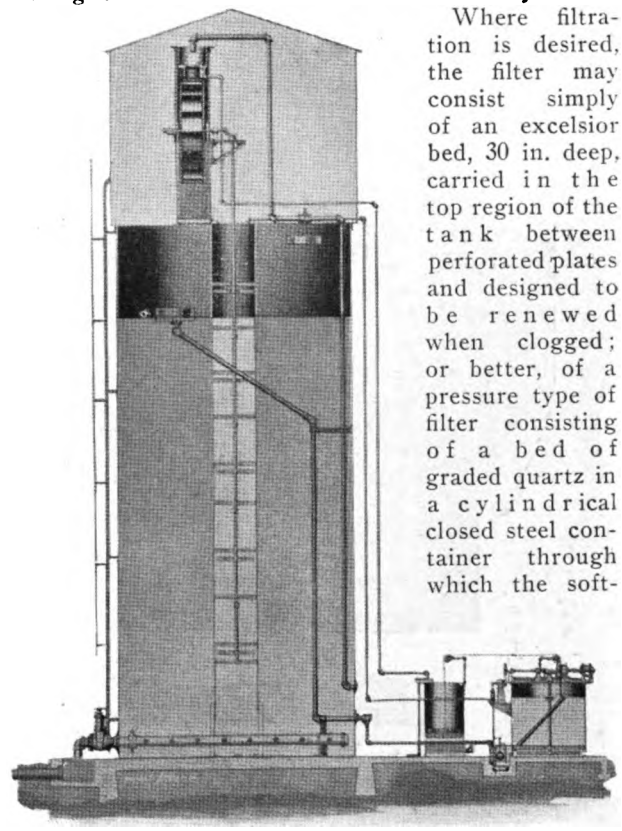


The Dividing Box

The control over the chemical feed is effected by means of a float in the control tank, which is connected by chain and pulleys to the free and open end of a swing pipe in the adjacent chemical tank. The float, rising with the water as it accumulates in the control tank in constant ratio to the amount of raw water entering the plant, lowers the swing pipe into the chemical solution in the same ratio; this solution in turn having its concentration maintained uniform throughout the several hours' run for which it was prepared, by a system of revolving inclined paddles and stationary baffles in the chemical tank.

The uniform solution thus discharging from the pipe in the prescribed and automatically regulated proportion is thence pumped into the stream of raw water as the latter enters the downtake, after which thorough mixing of the raw water and chemicals, on the one hand, and coagulation of the products of the interaction, on the other, are effected by the vigorous churning motion imparted by the joint action of the revolving inclined blades and stationary baffles as the mixture proceeds to the bottom.

Entering the large and quiescent region of the settling tank the softened water then rises to the outlet, or (if such provision is made) to the storage space at the top; the suspended matter, meanwhile, either settling out naturally and accumulating in the bottom of the tank, from which it is removed periodically through a system of perforated pipes, or having its removal from the water assisted by filters.



Cross-Sectional View of Water Softener

Where filtration is desired, the filter may consist simply of an excelsior bed, 30 in. deep, carried in the top region of the tank between perforated plates and designed to be renewed when clogged; or better, of a pressure type of filter consisting of a bed of graded quartz in a cylindrical closed steel container through which the softened water is passed after leaving the softening plant, and which is washed whenever desired simply by reversing the flow through it for a few minutes.

The prominent features of this type of softener are the automatic feeding of the chemicals in the exact proportion to the incoming water; the freedom of the proportioning parts from contact with the chemicals and consequent clogging; the thorough agitation of the chemicals and water in the downtake with the corresponding surety of proper reaction and settling; the facility with which the treatment can be adjusted at any time during the process; the location of all mixing and proportioning machinery on the ground floor, by reason of which the problem of attendance is usually simplified and such factors of cost as heating in cold weather reduced; small ground space in that the system ordinarily requires but a single tank; and low operating cost for the reason that the plants operate automatically, require little attention, and need be recharged but once in twelve hours.

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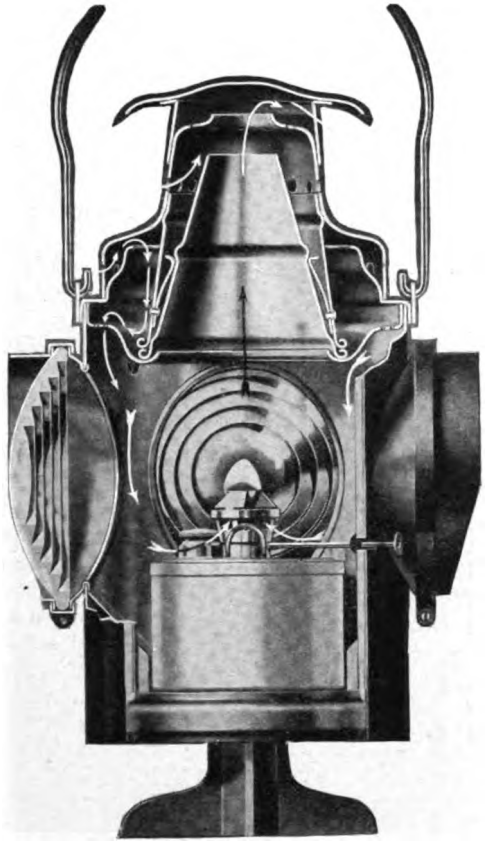
Oil Switch Lanterns

Peter Gray & Sons, Inc., Boston, Mass., manufacture switch lanterns or lamps, burners, oil cans, pails, tool boxes, waste cans and tinware. Their oil switch lanterns are made with top and bottom draft, or top draft only (as



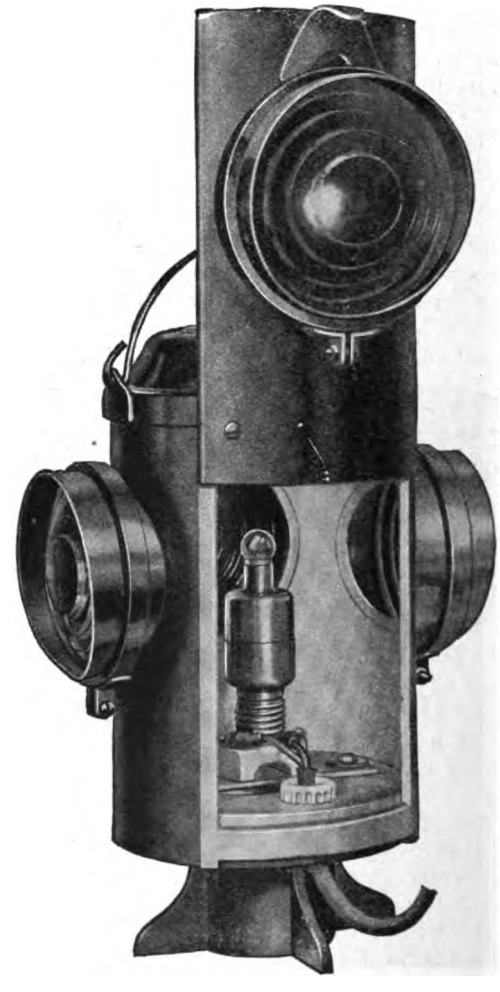
Gray-Boston Oil Switch Lantern.

shown), for either one-day or long-time burning, and with any size and color of lenses. Sockets are made to conform to the buyer's standard. The lanterns are finished in black Japan and baked. They may be equipped with painted or porcelain enameled day targets. All Gray-Boston Top Draft lanterns conform closely to R. S. A. specifications. The body is cylindrical, with vertical sliding wind and waterproof door. The Top Draft unit is hinged to the body, and houses a removable inner cone, which provides for easy cleaning. Every lantern is subjected to a wind velocity test of 100 miles per hour while burning.

Electric Switch Lanterns

In many installations electric switch lanterns offer the means of overcoming many disadvantages inherent in the oil burning types. Gray-Boston Electric Switch Lanterns consist simply of a neat cylindrical shell equipped with a sliding wind and waterproof door, and plain top, which serves as a holder for the four lenses. Thus the additional weight and height required by a top draft, and the expense and annoyance of cleaning lamps and lenses of soot, dirt, and oil, of storing and handling oil supplies, and of keeping burners in focus and wicks burning at a proper height, are eliminated. The feed wires enter the lantern through a bushed hole in the bottom. If required, a transformer which is housed within the lantern body, properly steps down the line voltage to the lamp voltage. The vertical alinement of the lamp is predetermined and fixed. The horizontal alinement is then adjusted and fastened rigidly when once the lamp is properly located.

This type of lantern was built especially for switch stand service and has proved a great success. While the first cost of the lantern and the installation of the usual electric equipment exceeds that of the oil burning type, the cost of upkeep is very low, the saving effected in one year in a number of instances exceeding the initial cost of the installation. The lanterns are not limited to the use of the particular lamp and transformer shown, but can be adapted to meet individual requirements, using either A. C. or D. C. line voltage, primary or storage batteries.



Gray-Boston Electric Switch Lantern.

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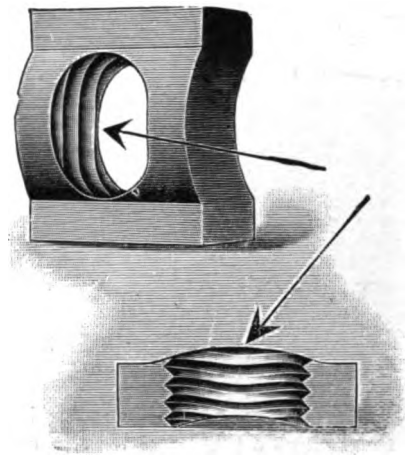
GRIP NUTS

General

The advantages of the Grip Nut in maintenance are most pronounced in the protection of bolts in frogs and crossings. Several of the larger railway systems make the use of grip nuts in such track work a standard requirement, while many of the leading frog and crossing makers use this type of nut extensively. Thus the lock nut is not an experiment, but is doing duty under heavy traffic and high speed movement in all parts of the world.

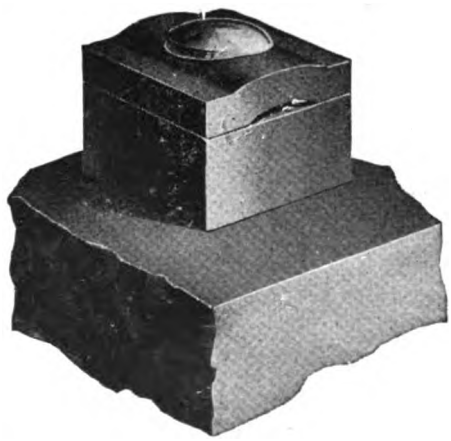


Lock Nut Feature

The automatic locking feature of the grip nut is effected through a slight deflection or bend in the threads of the top portion of the nut. This deflected thread is produced by the employment of automatic machinery which measures and gages the nuts to overcome the variation in thickness (steel mill tolerance) and insures uniform deflection and uniformity of locking. As the deflection is only in the top portion of the nut, it will start on the bolt easily, but when the nut is nearly applied it is necessary to use a wrench to complete the application and when turned to the full extent of the thread it becomes automatically locked in place.

Grip Lock Nut No. 1

The preferred type for the bolts in frogs and crossings is the cold punched Grip Lock Nut No. 1. This form is intended to be used where two nuts are desired, the main function of the second of which is to hold the first in place. The lock nut, however performs additional service, as the thickness of the lock nut supplies additional holding power. No greater length of bolt is required than with the ordinary heavy ⅝-in. nut lock, generally used with frogs when this means of holding is employed.

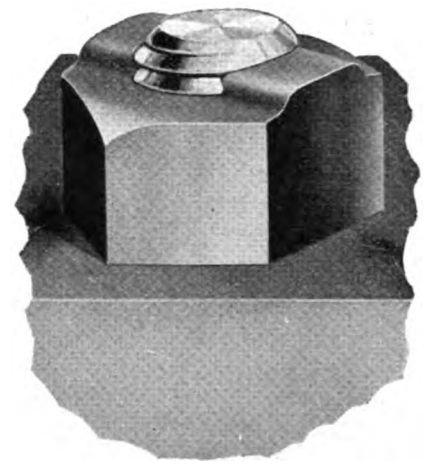


The Grip Lock Nut

The labor necessary to apply a grip nut is no more than is required to apply any of the various forms of nut locks. As the grip nut is made from a very ductile steel a nut may be reapplied many times without losing its locking effect. The nuts are made in as many different forms as are required to meet the demands of railroad service, which include locomotives and cars as well as track work.

Grip-Unit-Nut No. 3

The Grip-Unit-Nut is standard on several of the large railroads replacing the commercial nut and nut lock, a castle nut, or a nut with cotter key. In the grip-unit-nut the bottom of the nut is flat, and the head or arch is forged on the top of the nut. The nut is threaded and then passed through the deflecting machine where it is put under a slow pressure which causes the metal to flow. The displacement of metal occurs practically only in the three threads at the top portion of the nut and it may thus be applied easily. The advantages of this nut are four-fold: First, it is efficient, since it eliminates the deficiency due, to careless omission of a nut lock; second, it is economical, in that a less length of bolts will suffice; third, it is cheaper, because the cost of a grip-unit-nut is less than the combined cost of a nut and nut lock; fourth, as but one part is required in place of two, simplicity of design is obtained.



The Grip-Unit-Nut

Besides the Grip Lock Nut No. 1 and Grip-Unit-Nut No. 3, which are the types specially applicable to maintenance, the company also makes the Grip Holding Nut, the Grip Locomotive Nut and the Grip Piston Lock Nut. Where the tensile strain on the bolt is not a factor, but where the amount of vibration necessitates a position locking, as on locomotives and cars, the Grip Holding Nut has a special advantage.

Service

The Grip Nut Company specializes in the manufacture of one device, Grip Nuts, and has made the subject of the requirements of bolts and nuts its particular study. A service organization of practical men is maintained by the company to co-operate with prospective users of the product to obtain the best and most satisfactory results from the several types of grip nuts offered.

The works and works office of the Grip Nut Company are located at 5917 South Western Ave., Chicago.

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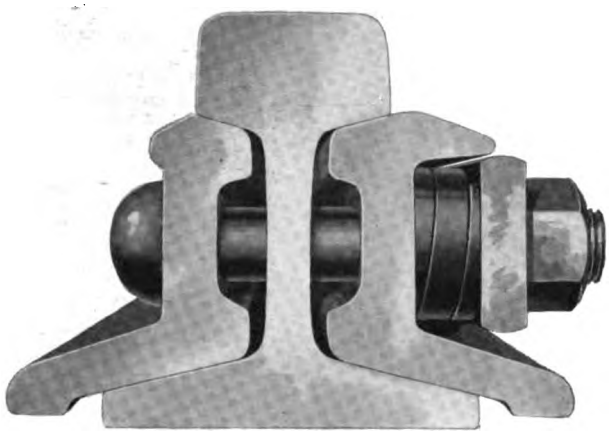
General

The maintenance of rail joints has always been a live subject among track men, while both the design and maintenance of joints have been given careful study by the Rail committee of the American Railway Engineering Association. All railway practice from the earliest days of the industry has emphasized the importance of the full bolting of the joints and the uniform tightening of every bolt in every joint. Neglected maintenance in this respect invariably results in definite injury to the rails and in inferior riding of the track.

The Hatfield Rail Joint Manufacturing Company, Macon, Ga., recognizing that the correct solution of the problem of the rail joint lies in the ability to keep the bolts tight, has perfected the Hatfield Rail Joint, and the Hatfield Fastenings for angle bar joints and crossings, which are designed to perform this duty effectively under the most severe traffic conditions. This has been attained through



Cross Section of Hatfield Rail Joint

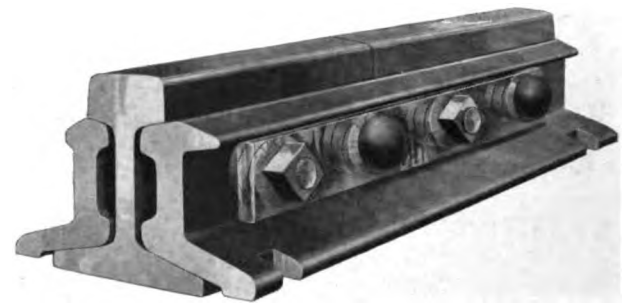
heavy type coil springs and the vibration bar, the combined action of which causes the entire joint to function as a whole, dividing the thrust of the traffic equally among all the bolts in the joint.

A number of the leading railroads have subscribed to the correctness of principle of the Hatfield joints by employing them for more than six years past in main tracks under heavy traffic moving at high speeds, in which a maximum of service with a minimum of maintenance has been demonstrated. The device has proved to be a positive means of fastening the angle bars to the rails and, by permitting uniform expansion and contraction at the joints, has preserved the resiliency necessary to smooth riding, adequate rail protection and low maintenance costs.

Hatfield Rail Joint and Fastenings

The Hatfield Rail Joint is an approved type of angle bar joint with permanently effective fastenings, developing the full strength of the reinforced spice bars. Its design avoids the excessive rigidity of base-supported joints and their destructive cupping and battering action on the rails when wear and stretched bolts permit vertical play of the rail ends. Correct distribution of metal in the splice bars provides the requisite strength for maintaining the surface at the rail ends, the head of the outside splice bar being specially reinforced, giving this bar a channel section. These joints are rolled only at steel mills with a reputation established for high quality of material and superior workmanship and finish of the product, from steel of any specified analysis and oil treated, if desired.

The joints are held in tight contact with the rails through the combined action of the Hatfield High Tension Heavy Type Springs and the Hatfield Vibration Bar, introduced between the outside splice bar and the heads of the bolts or their nuts. The coil springs are made of high grade spring steel, developing, under full compression, a tension of approximately 5,000 lbs. The bar, yoking the bolts together, but at all times free from direct contact with the splice bar, is a patented feature which has demonstrated its value in co-ordinating the action of the springs. This bar is of either a flat or angle section. The bar and springs, functioning together, prevent the nuts from working loose and keep all parts of the joint permanently tight.



Hatfield Joint for 100 Lb. A. R. A. Type B Rail
(Steel Vibration Bar in Phantom Outline)

These fastenings, which are the fundamental features of the Hatfield Rail Joints, are supplied with them or they may be specified for addition to standard joint material or crossings or existing joints in track.

Hatfield High Tension, Heavy Type Spring

Special Advantages

The Hatfield Rail Joints are easily applied in the track, and, their construction being simple, their first cost is in line with that of other types of joints. The fastenings permit of the staggering of bolts. The absence of a depending flange obviates the necessity for the respacing of cross ties at the moment rails are laid. The ability of these joints and fastenings to keep the bolts tight at all times effects a saving in maintenance expense and, of greater importance, supplies a definite assurance that the track and rail are not deteriorating through this cause. Hatfield Rail Joints and Fastenings are designed to keep the bolts tight in spite of wear, vibration, stretching, or the expansion and contraction of the rails.

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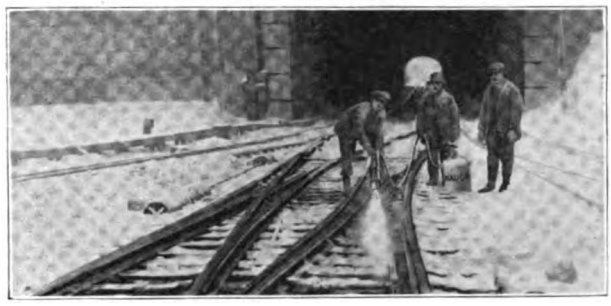
Oil Burners

Railways throughout the country have adopted the use of oil burners and torches and at present they are regularly employed in locomotive and car shops, where in the form of torches, forges, and furnaces, they provide the means, of heating for welding and straightening engine frames, truck frames, rails, pilot plates, beams, etc., of preheating metal members preparatory to



Removing Snow from Switches with Hauck Outfit

welding operations, of removing and setting tires, of heating rivets, melting solder, of kindling fires in locomotives, and of burning off paint or grease from metal surfaces preparatory to repainting. These devices have also firmly established themselves in the maintenance field where, in addition to uses similar to those in the shop, they provide the means of removing ice and snow from interlocking and switch mechanism, of burning weeds, of thawing out frozen water and steam pipes, frozen ground, ashpans, etc.

Hauck Burners

Very satisfactory equipment is made by the Hauck Manufacturing Company, Brooklyn, N. Y. The company's line comprises kerosene and crude oil burning torches, forges, and melting furnaces of various types and sizes for a wide variety of uses. In the manufacture of the products the company has specialized for over 20 years, during which improvements have constantly been made to enlarge the range of use or better to equip them to meet the increasing demands of railway service. The devices are of simple construction, perfectly safe, can be handled successfully by inexperienced labor, and are designed to withstand severe service and adverse weather conditions. They are widely employed by both steam and electric railways and are backed by excellent service records and reports of investigations. The Hauck Company will submit its burners to any railroad for competitive tests.

Hauck Hand Torches

Of the several types of torches manufactured by the Hauck Company, the hand torches Nos. 55 and 56 are distinctly adapted for thawing out frozen pipes, melting ice and snow around interlocking devices, burning off grease on detector bars, cranks, throw rods. The torches consist of a kerosene burner attached to the tank, all in a horizontal line, equipped with gauge, hand pump and safety check valve. The tanks are of steel, tinned inside and out, with seams and fittings welded or brazed. The Nos. 55 and 56 torches have 1½ gal. tanks, consume 3 qts. of oil per hour, and provide 22 in. flames. The burner of the No. 56 torch is on a non-leakable swing joint.

Hauck Thawing Outfits

For removing ice and snow from frogs, switches and signal mechanism, such as throw rods, cranks, pipe lines, and performing other torch work where a large capacity torch is desired and where compressed air is inaccessible or not convenient for use, the larger Hauck one-man and two-man type kerosene outfits are particularly adapted. Each outfit consists of a large kerosene burner connected by a hose to an upright cylindrical tank fitted with a hand pump, regulating valve and pressure gauge and with handles. The outfit is put into operation simply by pumping 30 to 60 lb. of air in the tank and heating the burner for three minutes. A single pumping provides sufficient pressure for several continuous hours. The one man outfits are of two sizes, No. 11T and No. 12T, weighing respectively, 30 lb. and 40 lb. complete, having 3 and 5 gal. tanks, 6 ft. of hose, a 6-lb. burner, and consuming 2 gal. per hour. The two-man outfits are of three sizes, the Nos. 7T, 8T and 9T, weighing respectively 80, 95 and 110 lb. complete, having 10, 12 and 15 gal. tanks, 12 ft. of hose, an 8 lb. burner consuming 3 gal. per hour. These outfits have been in daily service on railroads for several years.

Hauck One-Man Thawing Outfit

Hauck Concrete Heaters

Concrete work is now successfully carried on during the coldest weather and as safely as in the summer with the aid of the Hauck heater which is used to raise the temperature of the concrete. Temperature can be raised to 90 deg. F. or higher if desired. Rapid hardening takes place and the concrete thoroughly sets before freezing. Recommended by Portland Cement Association. The heaters are made in two different types: The Hand Pump Type, consuming kerosene only, larger than 10 ft. up to ¾ yd. material, No. 90. The for mixers up to 10 ft. material, No. 80; for mixers Compressed Air or Steam Type, consuming fuel, No. 40; for mixers larger than 10 ft. up to ¾ yard material, No. 20.

Hauck Concrete Heater

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Hayes Service

"We make it our business to help you get good results from every Hayes Derail you have all the time it is in track." This direct personal interest in every customer and in the satisfaction he gets from the material he buys has been a foundation principle with Hayes Track Appliance Co. since they began making derails in 1903. You like to feel when you have bought an article that your paying for it does not close the transaction but that the seller is a going concern ready to give you help when you ask it.

Another Hayes ideal is to stick to one line; they make only derails and the stands used with them, but they make these thoroughly well.

Assuming that a satisfactory derail is to be had, the transportation officer must consider whether he needs it. Is there a place on his tracks where he would like to make sure that no wheel can pass without the permissive action of an employe? The Hayes Co. points out that the clearance point of each turnout from the main line is such a place; that every car or train on a side track is a threat against the safety of the main track; that in a score of ways wheels without a restraining hand can get in motion and the clearance point be passed. The main track is invaded. The result may be serious. A derail simply and effectively removes this danger. In no other way can a clear main track be assured.

Safety Demands a Derail at Every Turnout

What side tracks need derails? The Hayes Co. answers: All those on which wheels may stand if these wheels when set in motion can foul the main track. A derail at every turnout gives complete protection. A division so equipped is easier to operate for every trainman knows the derail is there and learns to use it properly.

The side track derail is a requisite for safety in conducting transportation. While a signal merely indicates whether the track is clear at the present instant, a derail compels it to remain clear. The use of a derail is thus first of all a transportation matter. But the kind of derail to be used concerns both the maintenance of way and transportation departments.

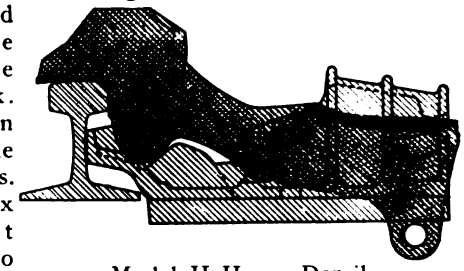
The men in the transportation department want a derail which is easy to handle and is effective; one which is out of the way for rerailing and does not weaken the track; one which takes up little room and gives maximum car capacity.

The trackman wants these qualities in a derail and more. Ordering and stock-keeping must be simple; one derail must fit many rail sections. It must readily be made a fixed part of the track but must not be fastened to the rail; creeping rail must not affect it. The derail must work in snow with little attention. It must have the fewest possible parts and must have nothing to get out of order. Every section must be carefully designed and the material must be right. The derail must have long life and must stand repeated derailments without damage.

The proof that the Hayes Derail meets these requirements is found in its wide use on nearly every railroad in North America and on many in other countries.

Types of Hayes Derails

Hayes Derails are made in various forms; there is a derail for every need. The sliding type with three-point bearing called Model H is most in demand and is an all-around derail. It is for operation by pipe line, by switch stand or direct by hand. There are two continuous shelf bearings near the rail and a single hook-shaped bearing at the rear of the guide box. Easy motion on and off the rail results. The guide box shortened at right angles to the rail gives ready access to the connection lugs and places the metal near the rail where it is needed to take wheel thrust. The corrugated tie flanges have widely separated bearings against the web of the rail but are not attached to the rail. These with vertical flanges, between the ties enable the guide box to be made a fixed part of the track. The derailing surface carries wheels across the rail without binding and without damage to wheels or derail. Two pieces make a complete derail; a one-piece derail block to receive and deflect the wheel and a one-piece guide box to hold the derail block in place.



Model H Hayes Derail

This derail when made to derail in both directions is called Model HX; a lighter single end form is Model G.

The hinged type of derail is for hand operation only. The derail block is swung over in a vertical semi-circle on and off the rail by hand. Model E is of this type; the double end form is Model EX and a lighter single end form is Model D.

The word "size" when applied to a Hayes Derail refers to the height of rail on which the derail will work. All sizes of any model weigh practically the same and are sold at the same price.

Size 4 is for use on rail from 3 in. to 4 in. high but may be used on rail more than 4 in. high.

Size 5 is for use on rail over 4 in. and up to 5 in. high but may be used on rail more than 5 in. high.

Size 6 is for use on rail more than 5 in. high.

In placing derails, a right hand derail goes on the right hand rail and derails toward the right looking in the direction of movement of a car to be derailed. Conversely with the left.

The expense of providing a road with side track derail protection is small. Compared with the cost of equipping a line with automatic signals the derail expense is negligible.

Not all roads can afford block signals. Traffic density, grades and curvature must be considered in each case. But the advantages of complete derail protection together with its low cost render it a requisite of good transportation practice on every road.

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General

The Hayward Company is one of the largest manufacturers of automatic buckets, with a bucket-building experience covering a period of over forty years. Hayward Buckets are built in all types and many sizes for every excavating, dredging, and rehandling requirement of a railroad. The Hayward Line includes Orange Peel, Clam Shell, Drag Scraper, and Electric Motor Buckets, Counterweight Drums, Grapples, Skid Excavators, and Coal Handling and Dredging Machinery. The following widely used types of buckets are but a few of the many Hayward Buckets available.

Trade HAYCO Mark

Orange Peel Buckets

Hayward Orange Peel Buckets are extensively used on railroads for all sorts of excavating, dredging, and rehandling work, including digging excavations for buildings, grading, digging packed gravel and frozen coal, building up roadbeds, digging and dredging for bridges and piers, etc. They are two-line buckets and may be operated by almost any type of double-drum engine.

The Hayward Standard Orange Peel Bucket is built in capacities from 2 cubic feet up. It is a ruggedly constructed bucket of the 4-blade type, and is known as an all-around contractor's bucket tor excavating, dredging, and rehandling work in general. Other Orange Peel types available for very heavy and special work are the Extra-Heavy for work such as digging out riprap and cribbing, pulling piles and stumps, etc.; an endless variety of jobs requiring a bucket of unusually sturdy construction throughout; the Multi-Power for digging clay, compact sand, or any other material of similar nature which is free from large rock or other large objects which will not go inside the bowl; and the Three-Sided, used principally for handling blasted rock and boulders.

Hayward Standard Orange Peel Bucket

Hayward equipment has been designed specially with a view to meet the requirements of speed, which in most cases determines the efficiency of a grading or material handling operation. The construction of the machines is simple and they are operated easily.

Clam Shell Buckets

Hayward Clam Shell Buckets, owing to the shovel-like shape of their blades, are particularly adapted to the rehandling of coal, ashes, sand, gravel, ballast, ore, and other loose materials, and to unloading cars, coaling engines, and digging out ash-pits. Like the Orange Peel, they are two-line buckets and may be operated by almost any type of double-drum engine.

Hayward Class "E" Ore Bowl Clam Shell Bucket

The Class E Ore Bowl type as shown is the most generally used of the Clam Shell Buckets and is built in capacities of from ½ cubic yard up. The other Clam Shell types are the Class E Regular Bowl for coal and ash handling and certain kinds of dredging work; the Extra-Heavy for unusually hard service; the Class H with exceptional penetrating power adapted to the digging of certain tightly packed materials; and the Class G Rope Reeved for operating in the bight of the line.

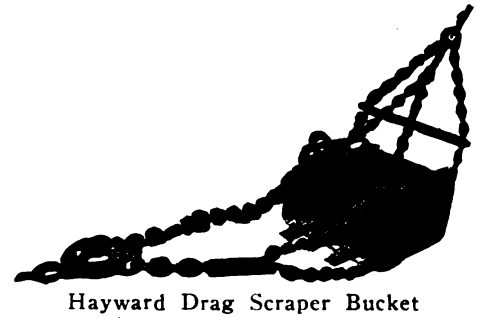
Electric Motor Bucket

The Hayward Electric Motor Bucket is a self-contained digging and rehandling machine with a motor-actuated mechanism; the motor an integral part of the unit. It can be hung from the hook of almost any double-drum hoist in a moment's time, and when the conductor cable is plugged in is ready for instant service. It is one-man operated by the simple movement of a controller handle. This bucket is generally used in connection with traveling cranes and monorail hoists for digging out ash-pits and loading or unloading cars on the siding. Built in capacities from 7 cu. ft. up.

Hayward Electric Motor Bucket

Drag Scraper Buckets

Hayward Drag Scraper Buckets are used to advantage for certain classes of railroad work where the material to be dug can be scraped up toward the operating machine. Built in capacities from ¼ cubic yard up.



Hayward Drag Scraper Bucket

All Hayward Buckets are ruggedly constructed to withstand severe service. To insure long life and low maintenance their wearing surfaces are protected by replaceable steel shoes, bearings, and bushings. Bucket parts of the same size are all interchangeable.

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General

Hubbard & Company are among the oldest and largest manufacturers of track tools in the world. Having been established in 1843, the company is well known today for its complete line of railroad tools and shovels and its nut locks. The upstanding feature of Hubbard service is the guarantee of all goods as regards material and workmanship, any tool found defective being replaced immediately free of all charges. The main office and plant of Hubbard & Company are at Pittsburgh, Pa., and principal offices are also maintained at New York and Chicago.

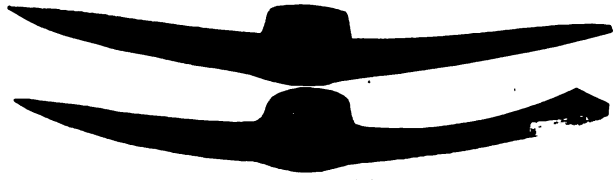
Hubbard Track Tools

The quality of the tools supplied the maintenance forces is of no less importance than their design. The Hubbard line of tools is manufactured of the kind of material, and with the details of treatment, tempering, forging, etc., that will best adapt the tool to its intended use. The standard tools are manufactured of stock sizes, which are available for immediate shipment, or they may be obtained of special sizes on order.

Hubbard & Company standard designs of track tools provide for four shapes of eyes, the No. 3 adze eye being the one commonly employed for picks. The cutting tools are polished on the cutting edges and have the remainder of the tool of a black japan finish. The picks are furnished in all black japan finished, as are the mauls, hammers and sledges, except those weighing 10 lb. or less, which have polished ends. The track chisels, wrenches, bars, etc., form special lines which, along with all Hubbard tools, have characteristics of proved durability through long service on many railroads.

Hubbard Picks and Tamping Bars

The pick and shovel have always been recognized as indispensable tools in track repair. The pick is of two general kinds, the clay pick for grading and the tamping pick for surfacing and tie renewals. The clay pick usually given preference is the No. 30 Railroad or



Hubbard Picks

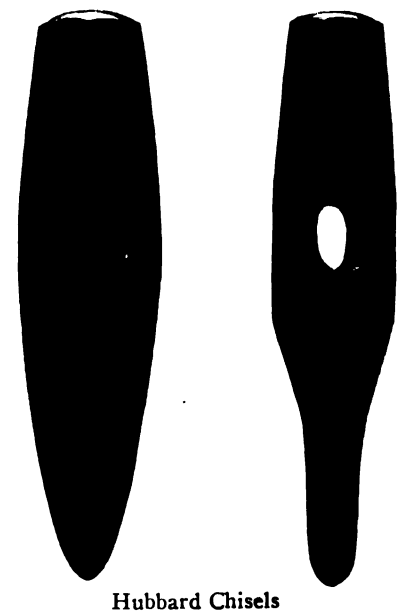
Clay pick, which is made in six stock sizes between 5 lb. and 10 lb., the one weighing 6½ to 7 lb. being recommended for general use. This pick has chisel and sharp point ends. It is made of a high quality of solid steel, with an oil finish or black japan finish as desired. The design of the pick adapts it to conversion readily into a coal pick when worn out in track service, and many railroads have made it a practice thus to transform old picks.

The type of pick generally preferred for surfacing and tie renewals is the No. 60 Railroads Tamping pick, with "V" shaped tamper and sharp point ends, although the "T" shaped tamper is sometimes desired. A feature of Hubbard design is the stock metal provided for drawing out at the tamping end, whereby the tool is kept in its original service as long as possible. The tamping picks are in sizes weighing 7 lb. and 8 lb., which are respectively 24 in. and 25 in. in length, the tamper end of both being 2½ in. wide. The company also supplies pick ends drawn out ready for finishing in the railroad's blacksmith shops with whatever end is desired. Tamping ends are also furnished for purposes of repairs, these weighing 2½ lb. each and being of either the "V" or "T" tamper patterns. The tamping picks, pick ends and repair ends are all made of a high grade of open hearth steel, and have demonstrated a marked durability in service.

The tamping bars furnished by Hubbard & Company are of five different patterns, but the two most generally used are the No. 258 R. M. A. Tamping Bar and the No. 256 Tamping Bar. The former is the type recommended by the Roadmasters' and Maintenance of Way Association. It has a chisel point on the handle and weighs about 13 lb. The latter has a spear point on the handle and weighs 12 lb. when equipped with a pipe handle, or 16 lb. with a solid handle.

Hubbard Track Chisels

The cutting of rails is a universal need on the railroad and both the economy and safety of the operation are largely dependent upon the quality and kind of chisel used. The effectiveness of the Hubbard & Company chisels is insured by the practice of testing every chisel on a rail before it is sent out. The chisels are supplied in two patterns, the ordinary wedge-shaped chisel being the one generally used, although the double hollow face chisel is preferred by some.



Hubbard Chisels

The former is know as No. 280 and its design provides ample breadth of face for drawing down in redressing. All Hubbard Chisels are made of high grade steel, highly tempered and tested. In order that its chisels may not fail because of improper usage the company has formulated the following suggestions for using and redressing the tool.

The handle should be securely fitted in the chisel, the chisel be held firmly to the rail and struck fairly on the head, using a sledge rather than a spike maul. It is important that a side or glancing blow be avoided. A chisel should not be used as a wedge or gauge and should be sent to the repair shop, when the head becomes battered or the point dull. In repairing chisels the battered part of the head should

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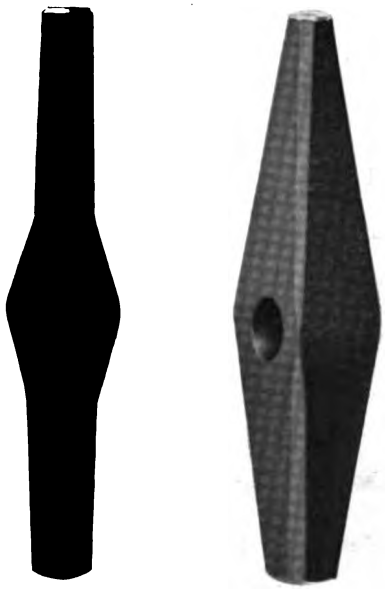
be cut off, care being taken not to overheat the tool. In drawing out the points, if the work is done by a power hammer, the steel should be heated slowly to an orange color; if the work is done by hand, to a lemon color. In tempering the point, the tool should be heated to a cherry color for ⅞ in. and drawn to a pigeon blue. The heads of chisels should not be tempered, and the chisel should be allowed to cool naturally after tempering. The cutting edge should be ground on a wet grind-stone or polished wheel, and the use of an emery wheel for this object avoided.

Hubbard Spike Mauls and Bars

The construction and maintenance of tracks require the use of spike mauls and various types of bars. The efficiency of spiking is largely dependent upon the design of the mauls furnished. The three patterns made by Hubbard & Company include the No. 311 Standard Pattern, with square heads beveled on the edges, one end being smaller to facilitate spiking in flangeway openings, which is the most usual selection; the No. 310 Pittsburgh pattern with round heads, one end similarly being smaller than the other; and the No. 312, Pennsylvania pattern which is standard on that road. The track and tie plug punches are necessary in spiking and Hubbard & Company furnish these in special steel, heat treated.



Hubbard Spike Mauls

The most popular selection among the four types of claw bars made by Hubbard & Company is the No. 252 R. M. A. Claw Bar, which has a pinch end and weighs about 30 lb. The No. 252 Claw Bar with Heel is the second in the extent of its use, and has a plain end. These bars are carefully designed to afford the maximum efficiency in pulling spikes, and are carefully tempered. The pinch and lining bars are of the usual patterns, the latter including the chisel, the diamond and the round point, the weight of each being about 26 lb. The spike puller is indispensable for withdrawing spikes from flangeways and its use in pulling spikes along the outside, on trestles may be a means of avoiding a serious accident. The No. 333 spike Puller has two or three knobs and weighs 1½ lb. and 2 lb., respectively.

Hubbard Track Wrenches

The tightening of bolts in the track is one of the most important of the routine operations in maintenance. To perform this duty efficiently as well as safely, it is necessary that the quality of the material in the wrenches and the workmanship shall be of the best and the design be adapted to the required service. All Hubbard & Company wrenches are drop forged and have the jaws heat treated and milled. The most common pattern in use is the No. 300 Single End Track Wrench, with the handle either round or flat, and of a length about 30 in. The No. 303 Double End Track Wrench, of straight pattern, is the kind usually preferred for the track walker.

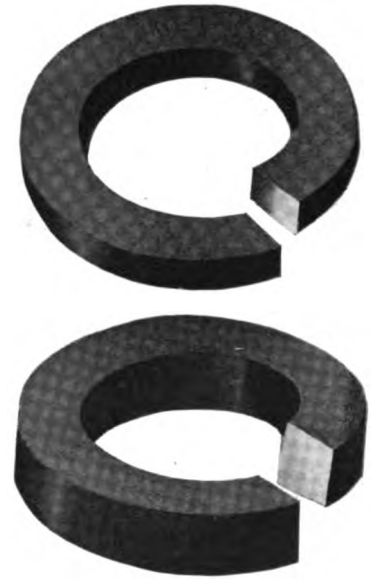
Hubbard Adzes

The cutting tools used in maintenance require a high grade of steel for their manufacture and an accurate tempering to insure that they will stand up in the hard usage to which they are subjected. The Hubbard & Company adzes for track use include the No. 331 Standard Railroad pattern with full head and bit from 3½ in. to 5 in., which is tempered in oil, and the No. 330 Adze with pick eye, which renders it a handy tool in section work.

Hubbard Adzes

Hubbard Nut Locks

The nut lock is one of the necessary track accessories and its kind and quality form a large factor in the maintenance of the railroad. The line of nut locks furnished by Hubbard & Company consists of four general patterns: the regular, the medium wide coiled flat, the broad or parallel pattern, and the high tension, the two latter being Nos. 362 and 363, respectively, and the ones in greatest demand. Both are made of keystone-shaped steel and are in all the sizes needed for track service. They are supplied in low carbon or Pennsylvania spring steel. The high quality of the material used in the manufacture of Hubbard nut locks insures that not only initial but permanent spring activity has been provided so that the nut locks can be used repeatedly with satisfactory results.



Hubbard Nut Locks

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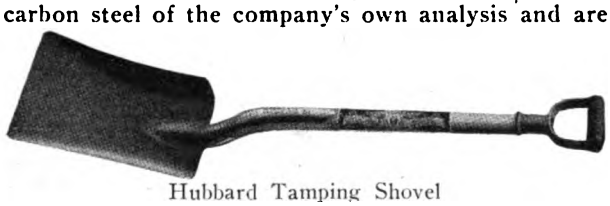
Hubbard Shovels and Scoops

The shovel is indispensable in maintenance for such routine work as grading, tamping track and removing snow; the scoop is employed in unloading cinders and handling other materials in bulk. Hubbard shovels and scoops form a comprehensive line, embracing every known application of these tools. The variety of patterns furnished affords a selection to cover all possible conditions of use. The track and grading shovels have stood the test of experience and have proved economical because they remain efficient until worn out. The snow shovels are built to afford the maximum wear in this service. The scoops, because of their frequent use in handling cinders, are specially designed to withstand the rapid wear from this source.

Hubbard shovels and scoops are made of high carbon steel of the company's own analysis and are



Hubbard Tamping Shovel

tested in the manufacture to assure the proper degree of hardness. They are fabricated carefully to the standard patterns or to dimensions when specified. The handles are of selected, straight-grained white ash, and the standard lengths can be varied to suit special requirements. The grip of the track shovels is either of wood in the common "D" form, or the malleable "D," which is preferred for certain uses; the grip of the dirt shovels is of the wood "D" form; and in the scoop the grip is tapered to fit the hand. Hubbard shovels and scoops are ordinarily supplied in black, although half polished or full polished blades can be obtained. Four grades are furnished, grade 1 being known as Hubbard & Co.; grade 2, as Wier; grade 3, as Wilson; and grade 4, as Buck.

Hubbard Track Shovels

For tamping track, Hubbard & Company supply tamping shovels T92, T93, and T94, the final figure indicating the size of the shovel. These have the malleable "D" handle, adapting them to the frequent operation of filling in lightly underneath the center of the tie upon the completion of the tamping. This provision is desirable to save the rapid wear which follows the use of the wooden handle for this purpose. For tamping dirt track, or for general purposes, the wood "D" handle square point track shovel is recommended, which is made in Nos. 92, 93 and 94. Both types are made of crucible steel and are supplied in grades 1 and 2, although grade 1 is generally pre-

Hubbard Track Shovel

ferred. They are made in the socket strap pattern, and are ordinarily desired in black finish.

Hubbard Dirt Shovels

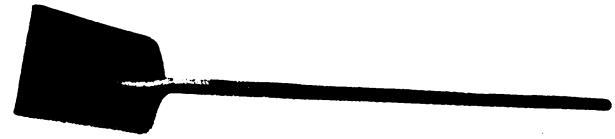
The operation of grading is a common one in maintenance and the handling of gravel and broken stone a not infrequent one, particularly in concrete work. Hubbard & Company offer for these uses their plain back shovels, with wood "D" handle, round point and socket

Hubbard Dirt Shovel

strap, which are known as Nos. 122, 123 and 124 in grade 1, the first figure being changed to 2 or 3 for the lower grades. For the deeper excavations a similar shovel with a long handle is supplied, the number of the first grade in size 2 being No. 132, and so on.

Hubbard Snow Shovels

The removal of snow from the tracks, platforms and walks is a never-ending duty on a railroad in the winter, and the flanging of the tracks is often done by hand and by extra labor of the most inefficient type. A specially strong and high grade tool is required in this service in which ice must sometimes be pried from the ties. Hubbard & Company supply the hollow



Hubbard Snow Shovel

back snow shovel in solid steel, with long plain wood handles or of wood with malleable "D" grip, the former being No. 500 and the latter No. 600.

Hubbard Scoops

The scoop may be regarded as in the same category of necessary track tools as the track, dirt or snow shovels. The design, no less than the quality, is of importance in the severe service to which the scoop is subjected. The Hubbard & Company locomotive scoops Nos.

Hubbard Scoop

23, 24 and 25, while designed primarily for use on the locomotive, are also the type most effective in maintenance operations such as handling cinders in unloading or removing them from the track. This scoop is made of crucible steel of the required degree of hardness, obtained by careful test, which insures for the tool durable wear while providing that it will not break with ordinary usage.

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General

Robert W. Hunt & Company, engineers, maintain a bureau of inspection, tests and consultation which is international in character. The organization is a highly specialized one, composed of competent and experienced engineers, chemists, metallurgists and inspectors, permanently employed in the divisions of engineering and inspection and in the various laboratories. The firm was established in 1888 and the personnel of the technical organization has been developed through more than a third of a century of conservative engineering work.

The service rendered by the bureau is world wide in its scope. The principal offices are in Chicago, while other offices are maintained in New York City, London, Eng., Pittsburgh, Pa., St. Louis, Mo., Mexico City, Mex., San Francisco, and Los Angeles, Cal., Cincinnati, Ohio, Seattle, Wash., Montreal, Que., Toronto, Ont., and Vancouver, B. C. These offices are in charge of resident members of the organization who are thus enabled to keep in close touch with the performance of the several inspectors stationed at the more prominent mills, shops, and manufacturing plants in these respective districts.

Organization

The efficiency of an organization is determined by the coordination existing among its various departments. In the Robert W. Hunt & Company bureau highly specialized skill of many kinds has been welded into a single unit. The organization has three main divisions, engineering, inspection and laboratory, and these are each subdivided into their appropriate departments. The Engineering division is devoted to (1) examinations and reports, (included in such services are the examination of and reports on iron ore, coal and cement properties and their development), (2) consultation and designing and (3) construction and testing; the Inspection division to (1) structural steel, (2) rails and fastenings, (3) cars and locomotives, and (4) materials; and the Laboratory division to (1) chemical science, (2) physical science, (3) electrical science, (4) the cement industry, and (5) microphotography. The engineering division aims to solve engineering problems in a manner to insure commercial success; the inspection service supplements the engineering work in the most practical way; and the laboratory service is a necessary adjunct of both.

Engineering Service to Railroads

Specialized technical advice is frequently desired on even those roads having a complete engineering organization, while it is necessary almost continually for the solution of a wide variety of problems on roads less highly organized. Among the more common questions on which the Robert W. Hunt & Company organization is prepared to advise are the designing of rail sections, the determination of the quality of cements and the examination of existing structures for present safety or for possible increase of the loading. Other special items to which the investigations of the bureau extend are power plants, for obtaining a lower cost of production; water supply systems, to assure continuity and economical delivery of water; water station machinery under various loads and operating conditions, to determine whether or not the efficiency of the pumping units can be increased; and motors or other electrical equipment, to insure that their efficiency, capacity, regulation and heating are in accordance with the specifications.

The inspection and engineering service of Robert W. Hunt & Company in concrete construction embraces the features of quality, proportioning, mixing, placing and finishing of the concrete; the proper spacing and anchoring of the reinforcing steel; and exact compliance with the detailed plans and specifications. In determining the quality of the cement the company is able to handle its cement testing with a maximum of efficiency and at a minimum of expense by having testers at practically all cement plants, as well as central laboratories at all important manufacturing centers.

Inspection of M. of W. Materials

The heavier duty required of rails by reason of greater traffic loads moved at higher speeds, has necessitated increased strength and weight of rail sections. This increase in strength and weight has tended toward a change in many of the details of rail manufacture, so that the necessity for expert inspection of the rails is well recognized. The advantage of the Robert W. Hunt & Company service in this particular is that a comprehensive inspection is available to the roads at all mills and at any time that their rails may be rolled. This inspection insures that the rails conform to the specifications, particularly as regards chemical composition, ductility, etc., and that no flaws, burrs, kinks or other similar defects exist.

With a view to securing a closer inspection of the rails, throughout the entire course of their manufacture, Robert W. Hunt & Company inaugurated its Special Inspection Service in 1912 at all the mills in the United States and Canada under which over 8,000,000 tons of rails have since been inspected. American Railway Engineering Association statistics, for the open hearth rails rolled in the United States in the five years between 1913 and 1917, showed that there were 23 per cent less failures among rails that received this special inspection than among those which did not have it.

The advantage to the roads of this special inspection consists in its application to the entire process of manufacture instead of merely the finished rails. The service includes a record of all the important data pertaining to each heat, ingot and rail, with a careful oversight of the mill methods to detect careless workmanship; for which object conditions at the furnaces, soaking pits, blooming mills, shears, rail mill and drop test are kept under constant observation. Reports of all operations for their standard or special Inspection service are furnished by Robert W. Hunt & Company to their clients. Since all rail failures involving personal injury or loss of life are now investigated by the Interstate Commerce Commission and the various state commissions, the desirability of the roads being equipped with this information is obvious.

The inspection of rail joints, track bolts and spikes, tie plates, rail anchors and other track fastenings by the Robert W. Hunt & Company service likewise embraces the whole process of manufacture, including physical and chemical tests, examination for pipes or other flaws, and measuring for accuracy of dimensions.

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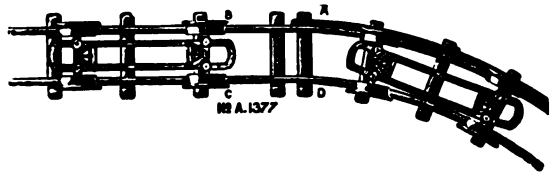
General

The C. W. Hunt Company, Inc., West New Brighton, N. Y., is a manufacturer of industrial railways and coal handling machinery. Its line of products includes Industrial Railway Tracks, Switches, Motor Operated and Push Cars, Scales, Electric Mine and Industrial Locomotives, Automatic Railways, Cable Railways, Conveyors, Coal Crackers, Skip Hoists, Bin and Hopper Gates, Weighing Larries, Manilla Transmission and Hoisting Rope, Rope Couplings, and Coal Tubs.

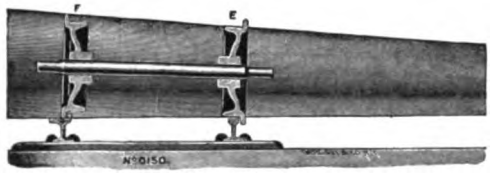
The company maintains a branch office in New York City, and is represented in Chicago, Boston, and Washington, D. C., by Phillips, Lang & Co., Inc., Day, Baker Co., Inc., and James P. Mewshaw, respectively. The organization includes an engineering staff prepared to furnish estimates and to render co-operative service to interested parties. The works are tributary to the Baltimore & Ohio tracks and include a wharf capable of accommodating lighters of every railroad centering in New York City.

Hunt Industrial Railway

The Hunt Industrial Railway is an outside gage system, the flanges of the wheels on all rolling stock running outside of the rail heads. The system is so designed in order to insure easy running of cars around short radius curves, and is based upon the principle that, in rolling, a conical surface takes a circular course naturally, while the movement of a cylindrical surface taking such a course, is one of sliding as well as rolling. Obviously on curves of short radius the sliding would be considerable and the effect of it is to oppose the forward motion.

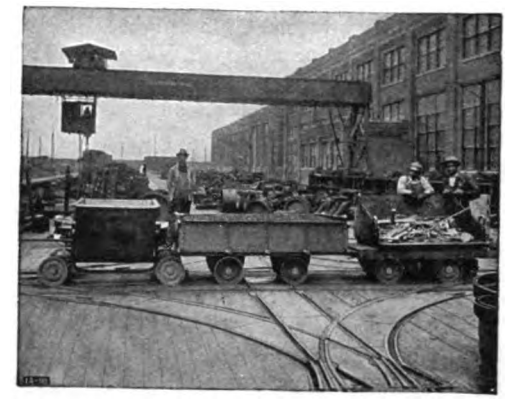


Position of Truck Axles on a Curve

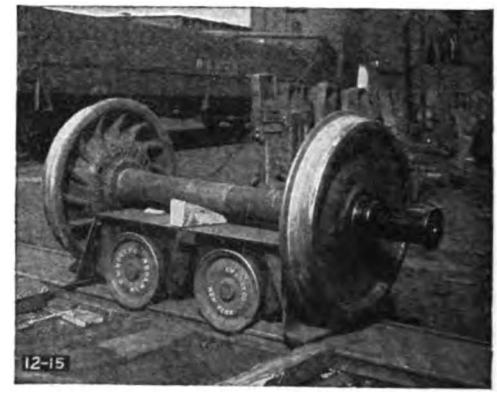


Theoretical Cone Made by Wheels on Curves

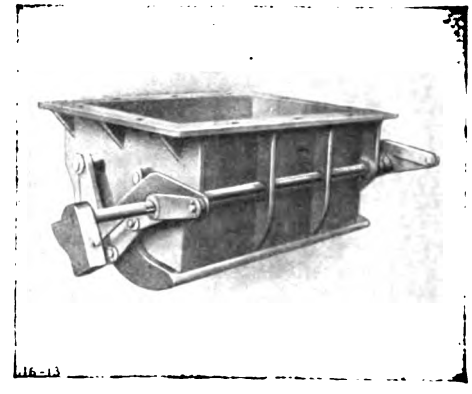
In the Hunt system the conical rolling surface at curves is obtained by making the outside rail of all curves of such a section that when a car is running over the curve the outside wheels run on the flanges instead of the treads. Obviously the bearing surfaces of each pair of wheels, comprising the tread for the inner wheel and the flange for the outer wheel, lie in the surface of a cone and inasmuch as the car bodies are pivoted to the axles midway between gages, thus permitting the axles of each pair of wheels to assume a radial position to the curve, the vertex of the cone is at the center of the curve. The tendency of the wheels to slip and slide on the curves is thus practically eliminated and the ease of running correspondingly increased.



Hunt Standard Cars for Handling Materials



Narrow Gage Car for Handling Mounted Wheels



Hunt Duplex Cut-Off Gate for Handling Bulk Material. Made in Sizes From 8-in. by 8-in. to 24-in by 36-in., and for Round Pipe

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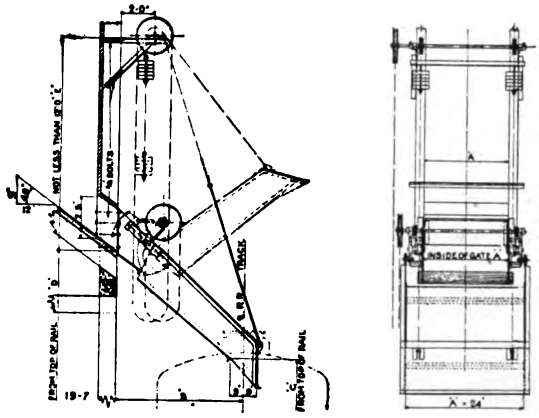
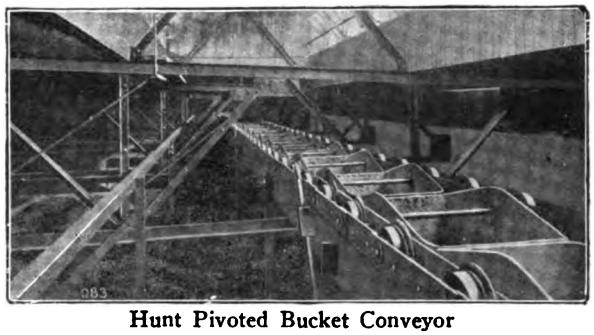
Coaling Station Equipment

The C. W. Hunt line of equipment for coaling stations includes the "Seaton" type of quick-acting balanced locomotive coaling chute (by means of which both rapidity and ease of operation are afforded in the coaling operation) and special designs of both the pivoted bucket type of conveyor and the skip hoist.



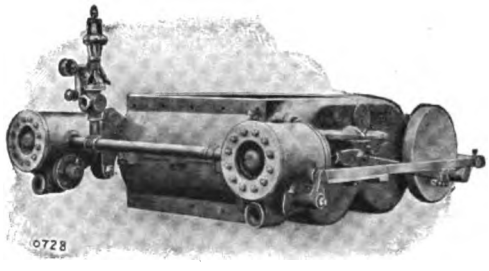
Hunt Quick Acting Balanced Locomotive Coaling Chute, "Seaton" Type

The Hunt Pivoted Bucket Conveyors, consisting essentially of a system of buckets pivotally suspended between two endless power-operated steel link



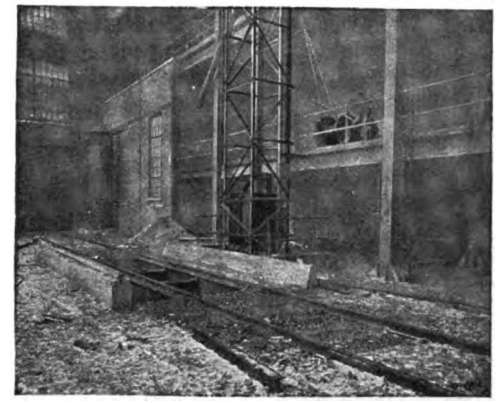
Hunt Pivoted Bucket Conveyor

chains, and arranged to receive the coal from a mechanical feeder below the receiving track and to carry it in a continuous passage until automatically dumped above the coaling bins, are installed in numerous coaling stations and power plants throughout the world. They are both durably constructed and reliable in operation, essential considerations where service is required of such equipment day and night.



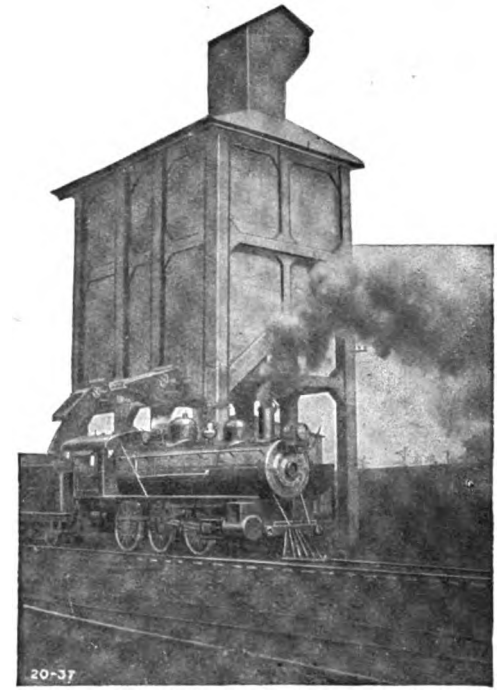
Hunt Double Roll Coal Cracker. Steam Driven. Also Made for Belt Drive

The Hunt Skip Hoist, a type of elevator usually preferred in coaling stations allowing but a limited space for hoisting, which consists of a system of one



Hunt Counter-Weighted Skip Hoist

or two buckets in separate shafts, alternately rising loaded from the receiving bins below the track to the coaling bins above, and descending empty, comprise the load-carrying buckets, wire hoisting rope, head and leading sheaves, an electric single drum hoisting engine with motor, a traveling cam control and electrically operated brake, bucket guides, loading pit valve or loading chute, control panel, and a push button station for operating the machine. The single bucket skip is counterweighted and provided with guides to guide the counterweight and bucket properly. Electric skips with drum type controller,



Concrete Coaling Station With Skip Hoist

and steam hoist friction-operated skips of high speed can be furnished if desired. The Hunt Skip Hoist can be operated equally as well in inclined as in vertical lifts.

Both the pivoted bucket conveying and skip hoist systems are furnished in capacities from 25 to 300 tons per hour.

C. W. HUNT COMPANY, INC., WEST NEW BRIGHTON, N. Y.

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NEW AND RELAYING RAILS

General

No subject is receiving more serious consideration today than that relating to the conservation of materials. Particularly is this true of iron and steel products, such as rails and similar track materials. For several years the mills have not produced rails in quantities commensurate with the requirements of the railroads or of those of other allied industries whose tremendous expansion was the accompaniment and logical sequence of the world war. It still remains necessary for the roads to exercise a close supervision over the use of steel rails and in numerous instances to seek outside sources of supply for the new and relaying rails required in routine maintenance, or for new construction.

Loading up Purchased Rails

The Hyman-Michaels Company, Chicago, are dealer in new and relaying rails, together with the necessary splice materials, and are also buyers and sellers of iron and steel scrap. They are one of the largest merchandisers of rails in the world, and have branches established in New York, Pittsburgh, Pa., and St. Louis, Mo. The principal function of such a concern is to serve as the intermediary between sources where these stocks originate and the ultimate buyers, whether these be railroad companies or private industries. The Hyman-Michaels Company perform the useful purpose of providing a means whereby these essential commodities may be obtained readily.

The Reclaimed Material

The principal sources from which the Hyman-Michaels Company obtain their relaying rails are those steam railways and electric interurban railways which have ceased to operate for one cause or another. Also surplus new and relaying rails are not infrequently purchased from operated roads, who find it profitable to dispose of such stocks not required for immediate use or which may have been acquired for a purpose afterward abandoned. The company has a well organized system of scouting in every field for material of this description. It also purchases large tonnages from the mills direct.

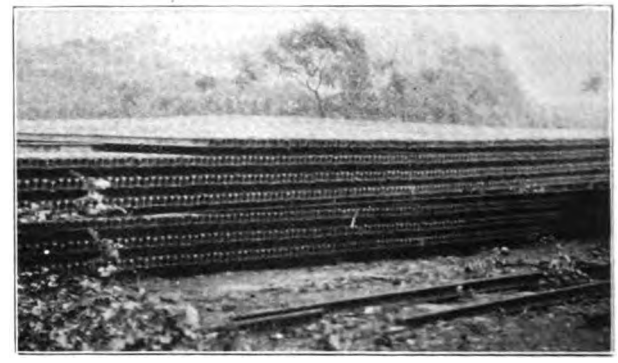
In the case of the defunct roads the rails, instead of remaining inert material to deteriorate through years of disuse, are obtained by the buying of the road outright, reclaiming all the material except the ties and storing it subject to sale to other railways or to private parties. As regards the surplus materials of the railroads the concern supplies the opportunity for the disposal of the rails, which thus diverts them into other fields of usefulness. The Hyman-Michaels Company disposed of 100,000 tons of rail for the U. S. Government, shipping them to all parts of the world.

An operation of loading up purchased rails is portrayed in one of the illustrations, and in another is shown the extent of the stocks thus accumulated. The company has its corps of efficient wreckers who take up the rails and other track work, including the frogs and switches, which are then shipped to a central yard to be classified into the different grades of relaying rail. The shorter lengths, and any material otherwise unsuitable, are sent to the mills as scrap. Thus all the material is kept moving into its proper channel.

The Market for Rails

The stocks held by the Hyman-Michaels Company may be obtained in lots of a few hundred feet or enough to build a railroad, no transaction being too large or too small for its attention. The railroads find this means of obtaining rails a certain and convenient one in many circumstances, and are thus greatly advantaged through this service. More recently, by reason of a definite shortage of new and relaying rails the roads have lacked the necessary amounts to fill their own requirements, and it has become a common practice to require private industries to purchase material direct for new siding installations.

While large quantities of the rail handled by the Hyman-Michaels Company are of standard weights from 50 to 100 lb. section, the lighter sections from 12 to 45 lb. supply a satisfactory material for siding, industrial, mining and lumber purposes. The greater wearing qualities of the lighter sections dating back a couple of decades is well known to railway men.



One of the Stocks of Purchased Rails

Service

The business of the Hyman-Michaels Company is conducted on the basis of providing a certain and adequate supply of new or relaying rails for sale to the railroads or industries, the need of which is often not only insistent, but immediate. The large stocks maintained by this company, reaching at times as high as 100,000 tons, furnish definite assurance that these needs can be amply met. The care used in the classification of the material, together with the record for fair dealing established by this concern through many years, insures the purchaser against receiving irregularly worn sections. The filling of all orders promptly is part of the general service of the Hyman-Michaels Company to which their entire organization is committed.

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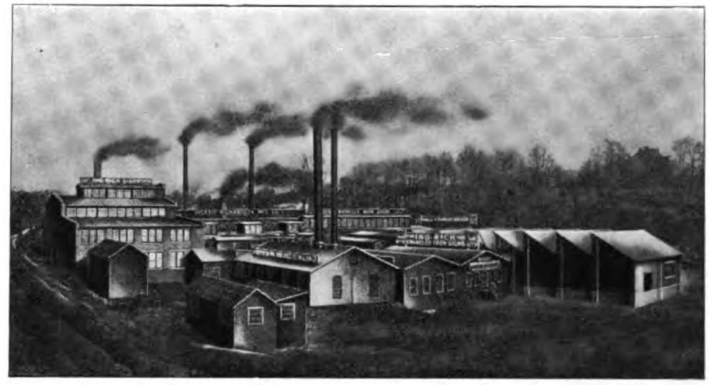
ENAMELED IRON SIGNS

General

The subject of signs and their effective use on the railroad is important enough to engage the attention of one of the standing committees of the American Railway Engineering Association. While most railroads have standard designs for many of their standing signs, such as road crossing warning signs, trespass signs, end of block signs, etc., there are innumerable situations where a special type of sign is required. The extension of electric power mains, the wide expansion of the "Safety-First" movement, and the requirements of legislation, have made necessary a large increase in the number of signs on the railroads. The full effectiveness of many of these signs is not obtained unless they are printed in colors, conveying a distinctive warning by that feature alone.

The Ingram-Richardson Manufacturing Company is the manufacturer of the Ing-Rich Porcelain Enameled Iron signs which are made in any size, color, or wording. These signs are particularly adapted to outside use and are guaranteed against fading, rusting or tarnishing for 10 years. The signs are brilliant in color, artistically attractive, convenient to put in place, cheap in cost and practically indestructible.



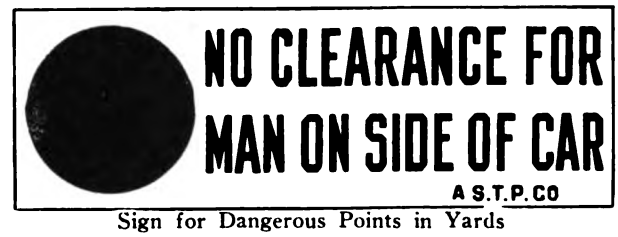
Plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

The Ingram-Richardson Manufacturing Company has its main office and one of its factories at Beaver Falls, Pa., and another factory at Frankfort, Ind. Branch offices are maintained at New York City; Chicago; Philadelphia and Pittsburgh, Pa.; Cleveland, Ohio; San Francisco, Calif.; Boston, Mass.; and Louisville, Ky.

The Ing-Rich Signs

Enameled iron signs are economical because they require no repainting or other maintenance. A combination of a number of different chemicals and minerals, scientifically treated and mixed, forms the brilliant enamel colors used on Ing-Rich signs. The base of these signs is a specially prepared steel sheet, of No. 18 gage, which is rolled at the mills according to the company's own specifications. The steel is first pickled and cleansed thoroughly, after which the enameling operations are begun with the application of a ground coat, which is burned into both sides of the steel sheet at 2000 deg. F. If white is to be used, it follows the ground coat, and two coats are applied, each one being burned separately. For each application of color thereafter there is a separate burning operation. Thus a sign in three colors receives a total of seven separate firings. The resulting colors are impervious to weather and amply justify the company's guarantee of the signs for 10 yrs.

One Form of Ing-Rich Enameled Sign



Sign for Dangerous Points in Yards

Ing-Rich signs are not carried in stock, but are made up specially to order in any quantity desired. They can be furnished in any combination of colors and, within limitations, can be lettered on both sides or on one side only. Signs are regularly manufactured lettered on both sides up to a size of 30 in. by 20 in. Beyond this size, when it is necessary to have a sign reading from both directions, two signs are recommended, each lettered on one side only and mounted back to back.

Ing-Rich Service to Railroads

Accidents are not only distressing, but they entail economic waste. Valuable workmen are injured, expensive machinery is wrecked, the smooth operation of the plant is disrupted. The provisions of Workmen's Compensation Laws impose expense upon the railroads for accidents, however they may be incurred. The use of brilliant warning signs posted at hazardous points is more than a human practice; it is the most practical form of real business economy.

The Ing-Rich warning signs afford the employee the benefit of the insistent warnings necessary to reduce accidents. They are always bright and distinctive because the vitreous porcelain enamel in which they are finished cannot absorb dirt or moisture. While they are guaranteed for 10 yrs., they will generally last from 12 to 20 yrs., retaining their original brilliance and coloring to the last.

The Ing-Rich signs are used generally for station names, danger signs of all descriptions, warning signs, instruction signs, and in fact for any purpose needing a high grade, conspicuous, attractive and extremely durable sign. The Ingram-Richardson Manufacturing Company not only has a large list of standard designs, from which an appropriate one for a given situation may be selected, but it also supplies sketches of any special designs specified.

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General

The Independent Pneumatic Tool Company, No. 600 W. Jackson Boulevard, Chicago, was incorporated in 1905. Its manufacturing plant at Aurora, Ill., on the main line of the Chicago, Burlington & Quincy Railroad, and also reached by the Chicago & North Western, is one of that city's largest industries. The company's two lines include piston air drills, reversible and non-reversible, for drilling, reaming, tapping, flue rolling, wood boring, and locomotive valve setting; grinding machines; the close quarter drill, a particularly efficient type of drill for maintenance use; pneumatic hammers for riveting, chipping, calking, driving stay bolts and flue beading; air hoists; holders-on; sand rammers; moisture separators; pneumatic hose and couplings; rivet sets, chisels, etc.; and electric drills and grinders.

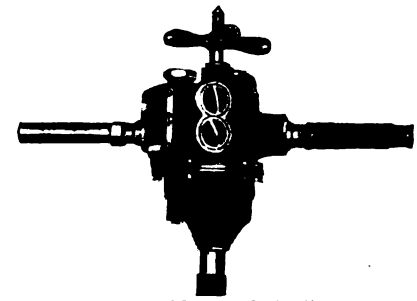
The Independent Pneumatic Tool Company has branch offices and service stations at 1463 Broadway (at 42nd St.), New York City; 1208 Farmers' Bank Bldg., Pittsburgh, Pa.; 1103 Citizens' Bldg., Cleveland, O.; 55 Garfield Bldg., Detroit, Mich.; 1721 Jefferson County Bank Bldg., Birmingham, Ala.; 61 Fremont St., San Francisco, Cal.; 411 Olive St., St. Louis, Mo.; 1230 Little Bldg., Boston, Mass.; 811 Denckla Bldg., Philadelphia, Pa.; 32 Front St., W., Toronto, Ont.; 334 St. James St., Montreal, Que.; Galt Bldg., Winnipeg, Man.; 1142-1144 Homer St., Vancouver, B. C. In addition to the above, the company has a branch in London, England, at 40 Broadway, Westminster, S. W. 1, for distributing Thor pneumatic and electric tools throughout Europe.

Piston Air Drills

After years devoted to careful study and numerous tests the Independent Pneumatic Tool Company offers its piston air drills equipped with Thor pressed steel connecting rods and pistons fabricated from Vanadium steel. The principles upon which these parts are designed has been proved to be mechanically correct. All parts are accurately fitted, heat treated, hardened, ground and lapped, making a complete assembly of superior design.

The Corliss valves used in Thor drills are so placed that the live air, which is magazined in the large chamber to the rear of the valves, is admitted over the full width of the edge which is distant from the piston only the thickness of the valve bushing and cylinder wall. This distance is equal on all four cylinders, which results in smooth action from the drills. Because of the large air chamber and parts, the effective working pressure on the piston is nearly equal to that of the pipe line.

The eccentric and eccentric straps are made with exceptionally large bearings. The crank shaft and roller bearings are made from the highest grade material obtainable. All rollers are hardened and ground and, by giving a line of support, will stand up under any forces exerted upon them without breaking or flaking. The telescopic feed screw is compact and has a large range of adjustment. The cylinder and gear case is made in only two parts, which are of cast steel, the upper part being the cylinder and the lower part the gear case. The construction is rigid, insuring correct alinement.



Thor No. 32-L Drill

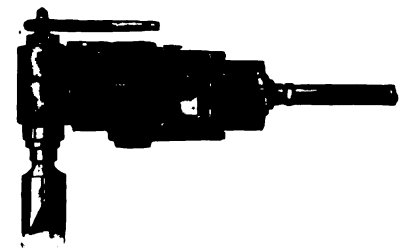
The reversible action in the throttle is obtained by moving the sliding collar on the throttle away from the sleeve and turning the sleeve full over to the right; while the drill is again run forward by turning the sleeve to the left. Compound gearing is employed in Thor drills, insuring great power and slow speed. Where extra heavy work is done a compound machine will perform the same service as a standard drill of much larger size. The sizes No. 1-X and 61 are equipped with an improved shifter mechanism for changing from high to low gear.

Close-Quarter Piston Air Drill

While the entire line of piston air drills has definite uses in maintenance the close quarter drills, by reason of working in close corners where the ordinary drills cannot be operated, are specially useful in maintenance, particularly for track bolt and bond wire drilling. The Thor Close-quarter drills of the non-reversible type are built in two sizes, No. 8 equipped with No. 3 Morse Taper Socket and No. 9 equipped with No. 4 Morse Taper Socket.

The spindle is at one extreme end of the tool and the motor at the opposite end. The motor consists of two cylinders parallel with each other and at right angles to the spindle. The pistons are double acting and operate on a two-throw crank. The air is taken in centrally between the cylinders, and the valves control the air as close to the cylinder bore as material allows. Geared to the crank shaft proper is another two-throw crank diametrically opposed, which operates directly on two oscillating levers centered on the drill spindle proper.

The lever operating crank is arranged to have its power stroke on the part of the revolution farthest away from the spindle, which makes the speed of lever more uniform, pulls forward considerably more than its half revolution and returns quickly. The crank being opposed, the motion of the drill spindle is continuous with only slight variation. The engine crank proper is not on the usual 90-deg. angle, but has an angle of 135 deg., thus allowing the two pistons to pull together when the position of the lever requires the greatest power. This makes the drill in a degree



Thor Close Quarter Drill

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self-regulative and tends to govern still further the speed of the entire revolution of the drill spindle.

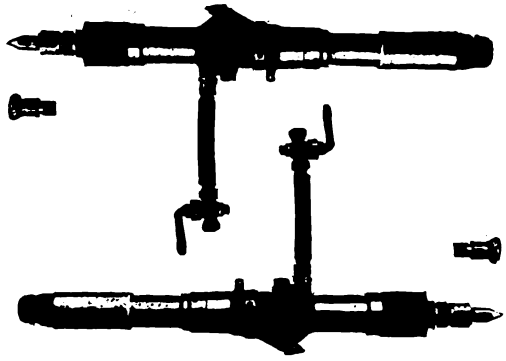
Thor Pneumatic Hammers

The riveting hammer is of constant use in the bridge and building department. The character of work required of it demands a construction that is at once simple and yet rugged. Thor Riveting Hammers have the barrel and handle made from a solid drop forging, thus obviating the necessity for a coupling between the barrel and the handle.

In the Thor hammers the main valve lies parallel

Thor One-Piece Long Stroke Riveting Hammer

with the main bore, but is not operated directly with the air in the downward stroke. Through an auxiliary valve which admits a slight amount of air the piston is started lightly downward. The main valve then opens, admitting the full volume of air direct and very close to the piston, which thus, from a



Thor No. 96 Self-Supporting Hammers

gentle start, receives an extremely forceful and quick acting blow and quicker return with practically no vibration.

Because of its one-piece construction, the Thor hammer is short and light and there is no possibility of any part of the hammer working loose from vibration. The throttle valve is arranged so that a light or heavy blow can be given at will. All parts are easily accessible and the hammers are handled easily while doing very effective work.

The Thor No. 96 Self-supporting Pneumatic Hammer is used principally for driving stay bolts, but is also useful for holding on in general reverting work. It is a combined hammer and holder-on, having two barrels, one with piston stroke of 9 in. for driving the stay bolt, and the other with 6½-in. stroke for use as a holder-on, which combination supplies the self-supporting feature. These hammers are used in pairs, driving both ends of the stay bolt at the same time.

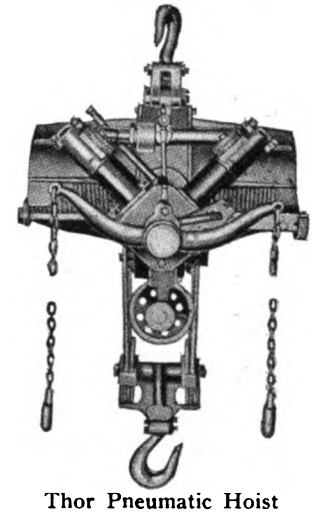
The Thor One-piece Long Stroke Riveting Hammers, No. 80 for driving hot rivets up to ⅞ in. or No. 90 for 1-in. rivets, equipped with inside or out-

Thor Chipping, Calking and Flue Beading Hammer

side trigger and wheer desired with the Safety-first rivet set retainer, are specially useful tools for bridge, structural and boiler riveting. These hammers drive rivets fast and well, and require a minimum of expense for maintenance.

Thor Pneumatic Hoist

The use of the air hoist is a common one at railway shops and at freight houses and material storehouses. The "Universal" Pneumatic Motor Hoist is so called because in case necessity ever requires it the air motor can be replaced with an electric motor. The air motor is double acting with two cylinders placed at right angles with each other and having a single-throw crank. The motor is easily controlled at any speed. The hoist is made in various capacities up to 6,000 lb. and in two lifts, 10 ft. and 20 ft. The special features include a drum with grooves for wire rope to prevent "pulling up."



Thor Pneumatic Hoist

Thor Moisture Separator

Thor Moisture Separator

The Thor Moisture Separator is a new device recently placed on the market for separating moisture, dirt and other impurities from air. The purifying of the air is accomplished with bafflers which eliminates all complicated mechanism or moving parts, which would be subject to wear. It is made in two sizes, Nos. 150 and 400, which have capacities respectively of 150 and 400 cu. ft. of air per minute.

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CONCRETE REINFORCING BARS AND TIE PLATES

General

The Inland Steel Company, Chicago, has developed a line of iron and steel products, many of which are used in large quantities by the maintenance-of-way department of the railroads. These products are manufactured from open hearth steel, rail carbon (Bessemer) steel and "Vismera" iron, a corrosion-resisting iron of great purity and strength.

In the open hearth classification are included concrete reinforcing bars, tie plates, angle bars, track bolts, and spikes. The rail carbon steel products embrace reinforcing bars and fence posts. The "Vismera" iron, in the form of galvanized and corrugated sheets, is much used for roofing and siding. It is also made into culverts and many other roadway and track structures.

The company has its works at Indiana Harbor, Ind., and Chicago Heights, Ill. Branch offices have been established at St. Louis, Mo.; Milwaukee, Wis.; St. Paul, Minn.; Denver, Colo.; Dallas, Tex.; Detroit, Mich.; San Francisco and Los Angeles, Calif.; and Seattle, Wash.

Concrete Reinforcing Bars

The several classes of reinforcing bars used in concrete construction are rolled from billet stock or are re-rolled from rails. The Inland Steel Company rolls reinforcing bars from medium or hard grades of open hearth steel at its Indiana Harbor works, and makes the bars of stiff Bessemer steel rerolled from selected old steel rails at its Chicago Heights works. In both processes the bars are turned out in plain rounds, squares or flats, and Inland deformed squares or rounds.

Inland Bond Bar

The Inland deformed bars were designed by expert concrete engineers and the sufficiency of the mechanical bond has been fully proved in tests made by the Iowa Highway Commission and by the University of Illinois. As a result of the former test Inland deformed bars have been approved for all Iowa state highway work.

The corners of the Inland squares are rounded to prevent splitting of the concrete. Bending, fabricating and setting are done easily with Inland bars. They are made in lengths up to 85 feet and in the weights shown in the table which follows.

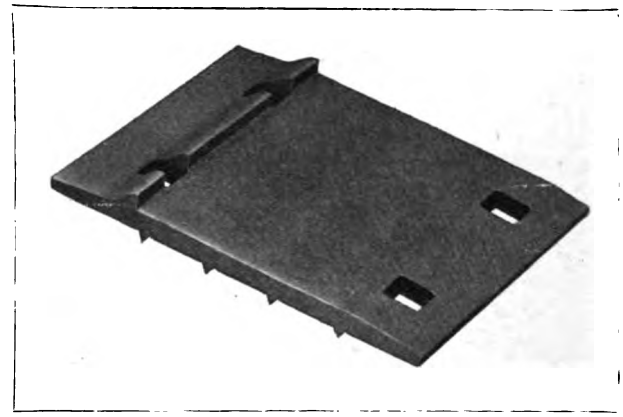
In addition to the sizes shown in the table the plain rounds and squares are furnished up to 2 in. and the flats of all required sizes.

Table of Inland Reinforcing Bars

Size in Inches	Weight of Square Bar per Foot	Weight of Round Bar per Foot	Area of Square Bar in Sq. In.	Area of Round Bar in Sq. In.
	□	○	□	○
⅜	.48	.38	.14	.11
½	.85	.67	.25	.20
⅝	1.33	1.04	.39	.31
¾	1.91	1.50	.56	.44
⅞	2.60	2.04	.77	.60
1	3.40	2.67	1.00	.79
1⅛	4.30	3.38	1.27	.99
1¼	5.31	4.17	1.56	1.23

Open Hearth Steel Tie Plates

While the A. R. E. A. specifications for steel tie plates permit their manufacture from either Bessemer or open hearth steel, the latter material has demonstrated great toughness and a long life under severe service. The Inland Steel Company owns its mines, blast furnaces, open hearth furnaces and rolling mills. Thus, in the manufacture of its steel it has complete supervision over the process from the ore to the finished product.



Inland Tie Plate

The care used by the Inland Steel Company in the manufacture of its open hearth steel insures a high quality of material. The steel is nearly free from harmful impurities, such as phosphorus and sulphur, and not being brittle, will stand vibration and the shock of repeated impacts. The steel is smooth, strong and homogeneous, and is thus resistant to corrosion and the action of brine drippings.

The varied sections of tie-plates manufactured regularly by the Inland Steel Company fit all weights of rail from 60 lb. upward, varying by 5-lb. stages, and of A. S. C. E., A. R. A. type A. and A. R. A. type B patterns; they also include intermediate joint and bridge plates. They are manufactured with 2 or 4 flanges, and in the flat bottom pattern, the several patterns having an inner as well as an outer shoulder when so specified. The width, length, thickness and punching are made to suit specifications, while special patterns of tie-plates are also rolled when desired.

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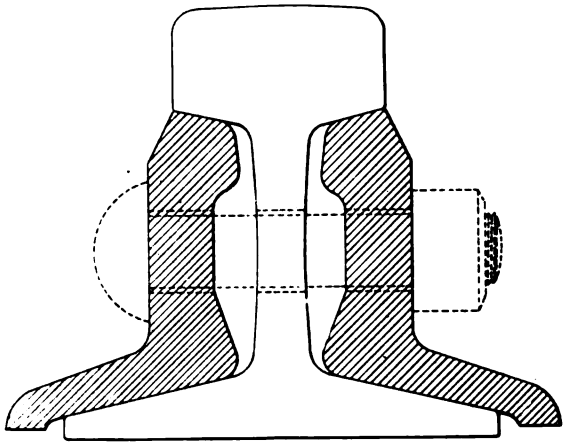
Inland Rail Joints

The essential track fastenings are the splices, spikes and bolts. The A. R. E. A. specification for joint bars requires that the material shall be steel made by the open hearth process. Many roads also give preference to open hearth



Inland Splice Bars

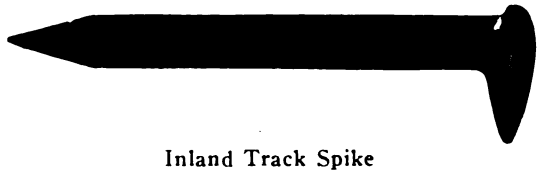
steel both for track bolts and spikes. The Inland Steel Company is equipped to roll standard and special splice bars, with 4 or 6-hole punching, with the holes alternately round and oval, all round, all oval, or round in one bar and oval in the other, and with any details of slotting.

Inland joint bars are made to the exact dimensions specified by the purchaser and the punching and slotting are done within allowable limits. The joint bars are finished smooth and true and the fishing angles accurately maintained. The bars can be furnished heat treated and oil-quenched when so specified.

Inland Track Spikes and Bolts

The phosphorus and sulphur content in the open hearth steel of which Inland spikes are made being low, an increase in the carbon is permitted, which is a specially important factor in the production of track spikes, inasmuch as it increases materially the strength and toughness of the steel without causing brittleness, so that the spike, while not so soft as to invite wear, is yet not hard enough to become brittle. The spike will therefore drive straight without bending, will not "head off," and will last well, resisting both wear and corrosion.

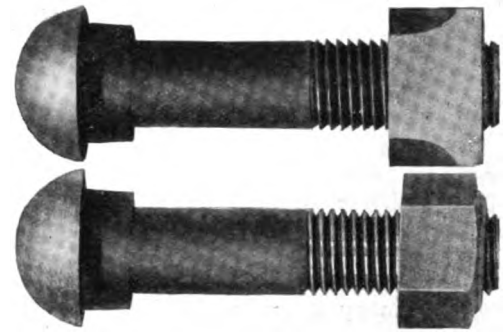
The Inland open hearth steel track spikes are made in 6½-in., 6-in. and 5½-in. lengths with ⅝-in.



Inland Track Spike

column, and in 6-in., 5½-in. and 5-in. lengths, with 9/16-in. column. They are assembled in 200-lb. kegs which contain per keg respectively 250, 260, 270, 310, 335 and 360 spikes.

The Inland open hearth steel track bolts are made in lengths ranging from 2½ in. to 12 in. and in diameters from ⅝ in. to 1-1/16 in. The heads are railroad standard; the threads are rolled or cut, either U. S. Standard or Harvey grip; and the nuts are square or hexagon, U. S. Standard recessed or Ideal recessed. Rolled threads are stronger, lighter, more durable and therefore more economical. The diameter of cut thread bolts is measured through both the threaded portion and the shank, while the diameter of rolled thread bolts is measured through the threaded portion only, the diameter of the shank being 1/16 in. less. Heat-treated oil-quenched track bolts of high tensile strength are also supplied. All bolts are put up in 200-lb. kegs unless otherwise desired.



Inland Track Bolts

Vismera Iron Sheets and Plates

There is a large and increasing demand in railway maintenance and construction for an anti-corrosive material to be used chiefly in the form of sheets for making culverts, for roofing and siding, for protection of the decks of wooden bridges, and for various other items entering into permanent structures. Vismera iron, by reason of its purity and strength, is well adapted to meet this need. The basic material entering into Vismera iron consists of Inland pure pig iron and current crop ends from the company's own rollings, together with carefully selected scrap.

This iron is refined to a point where it is 99.70 per cent pure iron with the usual allowance of 0.04 per cent variation in laboratory practice. The iron is then alloyed with approximately 0.20 per cent of pure copper, it being a well-known fact that pure iron and pure copper, scientifically alloyed, produce a material with great resistance to rust and corrosion and which also insures extraordinary lasting qualities.

In the production of Vismera iron the quality of strength is maintained by the retention of elements which do not affect its rust-resistance. The sheets and plates of Vismera iron, or those structures in which these are used, have demonstrated the enduring qualities of the iron when exposed to moisture, either above or below the ground.

Vismera iron galvanized and corrugated sheets are used in culverts and flumes and in roofing and siding. The plain sheets, both black and galvanized are used for tanks, stacks, cattle guards, eaves trough, conductor pipe, window frames, signs, stoves, etc. The plates and sheets are made in different gages, widths and lengths to suit these several uses.

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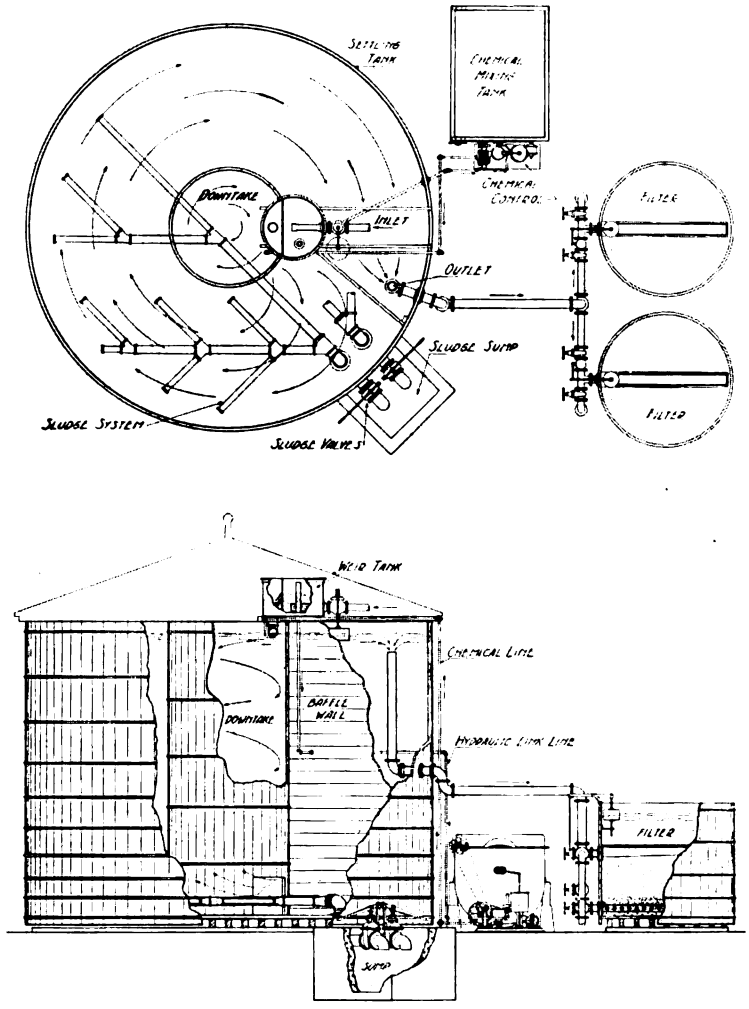
General

The International Filter Co. devotes its entire attention to the design and construction of water softening and filtration plants. Its equipment is adapted to various uses but it merits the attention of the railways particularly from the standpoint of the power plant and locomotive boiler by affording a means of improving boiler water.

The water softening and filtration plants of the International Filter Co. are the result of over twenty-five years' experience. They are successfully used on railways in various parts of the country as well as in industries and municipalities. They are of various designs and sizes for all kinds of service and embody many valuable and exclusive features. The success of the company in its installations is due largely to the fact that each plant is designed to suit the local conditions and requirements. The company is an engineering concern as well as a manufacturer and is prepared to handle all phases of the work from preliminary surveys to final installations including also the remodeling of existing plants. The company's factory and headquarters are in Chicago with offices in New York, Pittsburgh and San Francisco.



Sectional View of An International Water Softening Plant
Wood Tanks—Open Type Filters

Water Softeners

Of the several types of water softeners manufactured by the International Filter Co. the International variable flow softener is the one recommended for locomotive water service. This softener is of the lime—soda continuous flow type, handles water at whatever temperature it comes to the plant, and as the name implies, is adapted to treat the water at any rate of consumption up to a maximum. It consists of a large flat-bottomed cylindrical settling tank, a smaller reaction tank or chamber concentric with and extending from the bottom to the top of the settling tank, a chemical mixing and feeding system and one or more filters either of the closed or open type. The tanks are of steel or wood as desired, each having advantages over the other according to conditions.

The raw water, reaching the plant, first passes through a regulating valve actuated by a float in the settling tank. Where the water is obtained from a source of constant supply or from suitably controlled steam or electric driven pumps, the regulating valve serves the two-fold purpose of controlling the flow of incoming water up to the hourly capacity of the plant and also of starting and stopping the system. Passing this valve the water is proportioned by weirs into two streams, the larger of which enters the top of the reaction chamber. After receiving its treatment of chemicals the water then proceeds to the bottom, a whirling motion being imparted to the water column to obtain thorough mixing of water and chemical by discharging the stream diagonally against the inside of the reaction chamber.

Emerging from the bottom of this chamber through an opening at one side, the treated water rises to the outlet pipe near the top of the settling tank, its low velocity permitting the sediment resulting from the reaction between the chemicals and the substances in the water, to settle out. A vertical partition between the reaction chamber and the outlet causes the water to encircle the settling tank as it rises preventing the water from reaching the outlet before the expiration of the sedimentation period. From the outlet the water then passes to the filters which remove any precipitates persisting in suspension and, by exposing to the water an enormous sand grain surface, operate also to force to completion delayed precipitation which would otherwise give rise to after deposit in the mains. Sediment accumulating on the bottom of the settling tank is discharged through a sludge removal system operated by a conveniently located quick-opening valve.

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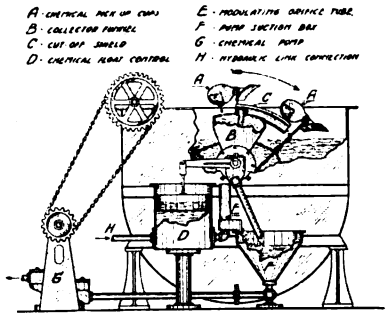
The chemical system is located wherever convenient on the ground floor. Chemicals for 12 to 24 hours' operation are mixed with water in a steel tank having a semi-cylindrical bottom. Plow-shaped agitators mounted on a horizontal shaft revolve in a vertical plane and provide the means of mixing the chemicals and keeping the mixture of uniform strength throughout the operation. The mixture is transferred to a funnel-shaped collector on one end of the tank by means of a series of cups mounted on the set of agitators adjacent to the collector. The cups are covered with screen to exclude coarse material and are designed in such a way that the chemical delivered through the orifice in each cup is independent of the speed of the agitators or the depth of the liquid in the tank, a very desirable feature in that it eliminates several common sources of inefficiency and irregular treatment. The chemical system may be driven by any kind of power.



International Chemical Feed and Control

The amount of this chemical received by the collector is controlled automatically in the following manner; that portion of the incoming water which is diverted from the main stream passes through a pipe line, or hydraulic link into a float chamber near the chemical tank and thence escapes through a modulating orifice tube that keeps the height of water in the float chamber proportional to the flow of water entering the softener. Variations in the level in this float chamber are transmitted mechanically to a cut-off shield above the collector by means of a float. The movement of the shield across the mouth of the collector enlarges or reduces the opening proportionately. From the collector the chemical flows into the pump suction box and together with the water discharged from the modulating orifice tube, is pumped into the reaction chamber by a specially designed chemical pump operated by the same power which drives the agitators.

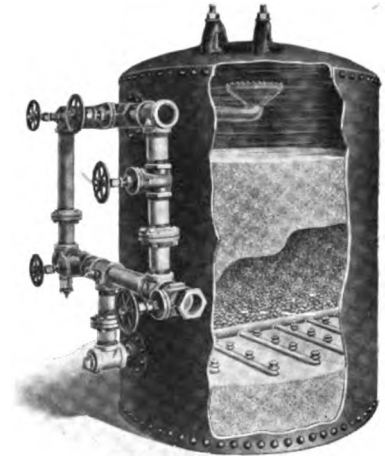
These systems require but little attention each day for replenishing the charge of chemicals, discharging the sludge, and washing the filters. They are designed to be operated by unskilled attendants. All operating parts are readily accessible for inspection or repair.

Filters

Mechanical, washable filters can often be used advantageously by railroads either alone for the purpose of removing sediment from otherwise satisfactory boiler water or as a finishing step in water softening, in the latter respect providing the means of overcoming serious defects of many existing systems. Some times the water leaves softening plants only partially settled, an occurrence which may or may not be due to faulty design. Frequently these systems are operated beyond their rated capacity owing to an increase in consumption which allows too little time for settling. Also in the handling of stream waters which are very turbid and usually quite soft during high water periods, the precipitates resulting from the slight softening required often are not sufficient to settle out naturally in an economical time. Filters which eliminate this sediment from the water often save much expense and annoyance by preventing after-deposit in cold water lines and injectors and the accumulation of it as sludge in service tanks. This surface action of the filtering medium is often sufficient to reduce the residual or "border land" hardness from one to two grains per gallon. Also the use of filters often makes unnecessary the use of additional or special chemicals employed to improve settling.

The filters of the International Filter Co., which are adapted to this kind of service employ special filter sand as a medium and are made in closed and open types. In both types the water enters at the top, is distributed uniformly over the filter bed, and passes down through the sand and layer of supporting gravel beneath it. Filtering takes place under pressure in the closed type and by gravity in the open type. From the filter bed the water passes into an underlying collector system embedded in concrete. This system consists of a central header pipe with evenly spaced lateral branches with or without specially designed strainer heads. These filters are thoroughly washed in a few minutes simply by reversing the flow of water by operating the control valves provided.

The closed filters, usually preferred for filtering the entire water supply of hotels, office buildings, public institutions and industrial concerns, are furnished in vertical and horizontal styles. These are of steel designed for pressures up to 100 lbs., the vertical styles ranging in diameter from 12-in. up to 96-in. and the horizontal styles being made in 7 ft. and 8 ft. diameters. The open type of filter is particularly adapted for service where the water is supplied from a coagulating or settling basin employed to remove from the water the heavier portion of the sediment. These filters are regularly used by municipalities and can often be employed to advantage by railroads for filtering muddy water. These filter tanks are built of cypress or California Redwood in diameters ranging from 6 ft. to 18 ft. All types of filters can be equipped with flow rate controllers and indicators showing when to wash and when to resume the filtering process, and can be arranged singly or in batteries.


International Sand Filter —Closed Type

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General

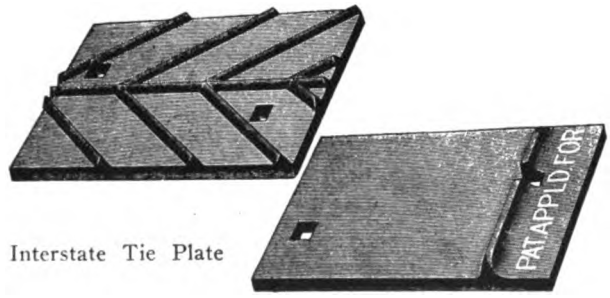
The Interstate Iron and Steel Company has works at East Chicago, Ind.; Grand Crossing, Ill., and South Chicago, Ill. At each of these works a specific type of iron or steel product is manufactured which is in common use on the railroads. The general office of the company is at 104 S. Michigan Ave., Chicago, and branch offices are maintained at New York City; Cleveland, Ohio; Detroit, Mich.; St. Louis, Mo.; Milwaukee, Wis.; St. Paul, Minn.; and San Francisco, Cal.

At the South Chicago works are manufactured open hearth steel ingots, billets and slabs and a continuous bar mill is also operated. Under the supervision of alloy steel experts the special steels department makes all standard analyses of open hearth alloy steel, including chrome vanadium, chrome-nickel and special analysis open hearth steel; these can be furnished in wire rods, bars, angles, channels, and special shapes.

At the East Chicago works are manufactured wrought iron and steel bars, shapes and tie plates. The bars are used for car and engine building concrete reinforcement and for tool repairs in maintenance-of-way blacksmith shops, the shapes in the bridge and building department, and the tie plates in the track department. Engine bolt bar iron and stay bolt iron also are made at this plant. The Grand Crossing works manufacture wire rods, wire, wire fencing, rivets, nails, tacks and staples. The wire regularly manufactured includes brace cable, signal strand, and galvanized telephone wire, which are used in the signal and telegraph departments. All Interstate wire is supplied in bright, coppered, galvanized or annealed finish as may be desired.

Tie Plates

From the standpoint of interest to the maintenance department the principal product of the Interstate Iron and Steel Company is tie plates, which are made both of rolled iron and steel and in the rib bottom and herring-bone bottom patterns. Because of the known advantages of wrought iron in resisting corrosion and the deterioration due to vibration, many roads specify this metal in preference to steel for certain services. The corrugations, either of the rib or herring-bone pattern, serve to keep the tie plates securely bedded in the tie, regardless of the movement of the track.



Interstate Tie Plate

The tie plates made at the East Chicago works conform substantially to the general principles of design, and to the specifications for physical properties, given in the A. R. E. A. Manual. They are of two detailed designs, one with a level seat and the other with a sloping seat to incline the rails inwardly, which latter provision is believed by many engineers to prevent undue wear of the rails and to reduce the internal strains within the rails.

Fence Wire and Wire Fencing

Interstate products, which are of an importance in the maintenance department secondary only to that of tie plates, are fence wire and wire fencing. The increasing cost of wood for all uses and its liability to destruction by fire have led to the general use of fences with the line wires in single strands, or of a woven mesh construction, supported on posts of steel or concrete. The Grand Crossing wire is made from open hearth steel, of a selected quality and analysis, from the company's own steel mills. The works specialize in the manufacture of the Improved Glidden barbed wire, which is made in thick set (hog wire) or regular (cattle wire), and of woven wire fencing.

The Grand Crossing square mesh, hinge joint, woven wire fence is made entirely from the pig iron to the finished fence. By employing a steel of known quality a product is assured which combines strength with a proper degree of stiffness. Special machinery is employed for weaving the wire into the fence, so that all parallel wires are of exactly the same length. The machines introduce the tension curves in the line wires in a manner to double the elasticity afforded for expansion and contraction, and the hinged construction makes the fence both flexible and tight.

The Standard wire fencing of the Grand Crossing works is made with No. 9 gage top and bottom wires and No. 11 gage line and stay wires. The woven fencing is in heights of 26, 32, 39, 47, and 54 in. A special fence somewhat lighter than the Standard is made by the use of No. 10 top and bottom and No. 12 line and stay wires. The 26-in. fence is frequently employed with the addition of two top strands of barbed wire, a construction which serves to turn hogs or any kind of cattle.

Concrete Reinforcing Bars

The most important factors in concrete reinforcement are the tensile strength and elastic limit of the reinforcing bar. Other things being equal steels having the highest elastic limit, or yield point, will be the most satisfactory for reinforcement. Next in importance is the adhesion between the concrete and the steel. When the adhesion between the concrete and a plain bar is not sufficient, resort must be had to a mechanical bond. This has been obtained by twisting or corrugating squares or flat rods or bars, adding rivets to the flat bar, or deforming round rods.

The East Chicago works of the Interstate Iron & Steel Company make reinforcing bars of soft and high carbon steel in rounds, plain and twisted squares, and in squares with projections, which are called Swastika concrete reinforcing bars. The latter and the rounds are from ½ in. to 1¼ in., the squares from ⅜ in. to 1¼ in. The specifications for the cold twisted squares are severe enough to insure a satisfactory bar for any kind of concrete construction. The East Chicago works also manufacture regularly bars of open hearth steel in rounds, squares and flats.

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Kreolite Wood Blocks

The Jennison-Wright Company, Toledo, Ohio, together with The Midland Creosoting Company, Granite City, Ill., manufacture several kinds of wood paving blocks, but they direct the attention of the railroads particularly to their Kreolite Lug and Kreolite Groove Blocks. These blocks have contributed in a large way to the

Kreolite Lug Block

Kreolite Groove Block

present great and increasing popularity of block pavement in railway and industrial service, a field in which they are extensively employed. The distinctive feature of these blocks lies in the effectiveness with which they prevent bulging or loosening of pavements due to wetting or drying.

Specifications

To insure results in block flooring consistent with its broad claims, the company has prepared specifications to govern the construction. The following apply to factory and mill type work.

FOR MACHINE SHOPS, FACTORIES, ETC.

Sub Grade: To prevent yielding, the sub-grade shall be well compacted by rolling or tamping, or otherwise prepared, before laying the concrete base.

Concrete Foundation: The minimum thickness of the concrete base shall be not less than four inches and shall increase in thickness, depending upon the load the floor is designed to carry. Under extremely heavy loads and impact where settling of the sub-grade is liable to occur, reinforcements shall be placed to distribute the load. The concrete base shall be composed of one part Portland Cement, three parts sand and six parts stone or gravel. All concrete shall be poured immediately after mixing.

The top of the concrete foundation shall be brought to a true, smooth and even finish exactly the depth below the finished floor level, corresponding with the depth of the block to be used. This shall be accomplished by applying a mortar finish with a long handled wooden float or similar device. Care must be taken to see that there are no projections in the concrete that will form an uneven bearing for the blocks.

Kreolite Concrete Coating: After the concrete nas thoroughly dried out, it shall be swept clean and given a thin, even coating of Kreolite Bitumen, not exceeding ⅛ in. in thickness. The coating shall be allowed to harden before laying the blocks and shall not be applied over 20 ft. in advance of the block laying.

Laying the Blocks: Upon the base, as above prepared, the blocks shall be laid tightly together, with the grain vertical; the courses of the blocks shall be kept straight and parallel, starting from one side of the building and carried through to the other side; all joints shall be broken by a lap of at least two inches. In truckways, and whenever possible, the blocks shall be laid with their length at right angles with the line of traffic.

Blocks to Be Tightened Before Applying Filler: A—Dry floor conditions, heated interior rooms, etc. Kreolite Groove Blocks shall be used, and after every four rows of blocks shall have been laid in place, a piece of 2 in. by 4 in. planking shall be laid along the outside edge of the blocks and the courses driven together as tightly as possible. The blocks in each separate row shall also be tightened lengthwise before the filler is applied, by forcing the blocks together from the ends, with a lever, pick or other instrument.

B—For alternately wet and dry conditions or floors occasionally subjected to moisture. Kreolite End Lug Side Groove Blocks shall be used and shall be laid and tightened in the same manner as the Kreolite Groove Blocks just described.

C—For wet conditions and floors subjected to moisture and high humidity. Kreolite Lug Blocks, which provide individual expansion joints between each block, shall be used and shall be laid with the lugs merely in contact with the adjoining blocks.

Expansion Joints: Against the walls on all sides of the floor, as well as around all columns and other obstructions, a bituminous expansion joint one inch in width shall be formed by first laying a strip of that width and after removal, filling the space to within an inch of the top with Kreolite Bituminous Filler.

Application of Kreolite Bituminous Filler: After the blocks have been laid in place and brought to as true and level a surface as possible, the joints between the blocks shall be filled with Kreolite Bituminous Filler applied at a temperature of not less than 350 deg. F. The filler shall be applied by flashing over the surface of the floor, using a rubber-edged squeegee to force it into the joints. Care must be taken to see that the filler penetrates the full depth of the blocks and that the joints are completely filled at the time of application. With proper care, the floor space will be almost free from filler. Dry, sharp sand shall then be swept over the floor, completely covering the blocks, same to be left on the floor until the blocks are well set, if possible for a period of three weeks. Traffic during that time will wear off the thin film of filler left on the surface.

Rough Concrete Base, How to Rectify it: If the concrete base which is furnished is not smooth enough to form an even bearing for the blocks, it will be necessary to bring it to such a surface by the application of a mortar finish. If there is sufficient time to permit this mortar finish to set up, it can be applied wet in this condition, being smoothed out with a wooden float, the operation then proceeding as outlined above.

Dry Mortar Cushion: If time will not permit the above procedure, the mortar may be applied dry, as follows: It should be composed of one part Portland Cement and four parts sand. This should be thoroughly mixed dry, luted to an even density and a true, even surface, just deep enough to cover the projections in the concrete and conforming exactly with the contour of the finished floor; then well sprinkled with water just before the blocks are laid. The laying of the blocks should then proceed upon this cushion as outlined above and immediately either tamped or rolled smooth before applying the Kreolite Bituminous Filler and before the mortar cushion has had a chance to set.

FOR MILL TYPE BUILDINGS

Sub Floor: The sub-floor may consist of T. & G. planking, matched lumber, maple, or any material which will furnish a solid, smooth and level base for the blocks to rest upon. If the blocks are to be used to resurface an old wearing surface, care shall be taken to secure an even bearing for the blocks.

Kreolite Felt: A membrane of 2-ply Kreolite Felt shall be placed over the sub base, but not cemented to it. The top shall be mopped thoroughly with hot Kreolite Bitumen, which shall be permitted to harden before laying the blocks.

Water Proof Construction: Where waterproof construction is desired a second layer of single ply Kreolite Felt shall be lapped over and cemented with Hot Kreolite Bitumen to the 2-ply membrane described above. The top shall then be mopped with hot Kreolite Bitumen as described above.

Specifications for laying the blocks, tightening the blocks prior to the application of the filler, providing expansion joints, and applying the Kreolite Bituminous Filler are the same as for the concrete base floors.

Wood Preserving

In addition to manufacturing wood blocks, the company is a large merchant of treated lumber for railroads, such as ties, piling, poles, etc., and is prepared to build according to plan and treat after assembling, such structural shapes as trestle bents, doors, stringers, etc.

JENNISON-WRIGHT COMPANY, TOLEDO, O.

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Asbestos Roofing

The roofing used on railroad buildings, whether they be stations, sections houses, engine houses or main shops, must be built of the most permanent material obtainable. They are all exposed to materials' most destructive agents—smoke, soot and corrosive fumes. And Asbestos Roofing successfully meets these conditions, for it is more than a roof covering, it is a roof protection.

Asbestos Roofing is asbestos made into roofing that provides the best investment possible—the longest lived roof and a roof safe from communicated fire.

Below are Johns-Manville Roofings suitable for railroad requirements:

Flexstone for sloping roofs.
3 & 4 Ply Asbestos Built-up for permanent structures.
Corrugated Asbestos Roofing for skeleton frames.
Asbestos Shingles for decorative roof treatment.

Transite Asbestos Smoke Jack

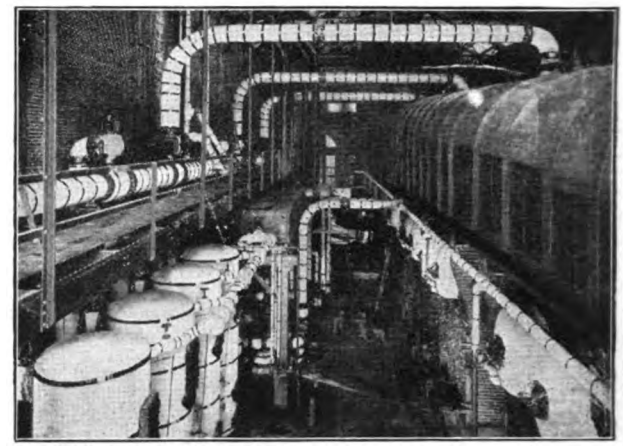
The best of metal is out of its element as a smoke duct. Subjected as it is to heating and cooling, it is sure to scale or deteriorate, making it easy prey to the highly chemical action of stack gases and moisture.

The Transite Asbestos Smoke Jack is so light in weight that it doesn't tax the roof members. It is made of Transite Asbestos Wood and, without painting or attention of any kind, will withstand "gassings," sparks, weather and frost without deterioration.

Pipe Coverings

One of the most important results of the development of asbestos has been the saving of heat through insulation. Materials have been developed, built on asbestos as a base, that retard the escape of heat from boilers, furnaces, pipes and flues.

Twenty-six years specialization directed by the highest engineering talent, has enabled this company



to produce insulations of exceptional efficiency and durability under every service condition.

Below is a list of pipe insulations designed for various classes of service:

High Pressure—Asbesto-Sponge Felted Sectional Pipe Insulation.

85% Magnesia Sectional Pipe Insulation.

Medium and Low Pressures—Asbestocel Sectional Pipe Insulation.

Insulation Problems—We have a solution for most of your conditions. Ask for Engineering Service.

Mastic Flooring

In locomotive, machine and back shops, where shop work is heaviest, blows most severe, "wear and tear" most strenuous, Mastic flooring has a great advantage over any other material. No two "Mastics" are necessarily

alike; each one is tempered to suit the exact service conditions to be met.

The Mastic floor of a machine shop, subjected as it is to the repeated hammer blows of heavy parts, must be of tougher "temper" than one designed and "made to fit" the conditions of wear imposed by foot traffic only. It can be laid in any degree of hardness required—to suit the severe usage in a baggage room, or the wear on concourse or station platform.

And Mastic flooring will also meet temperature extremes far better than any other monolithic floor. It may also be laid over old floors, if such foundation is stable and firm.

Other Johns-Manville products used by railroads—High Pressure, Low Pressure and Sheet Packings. High Temperature Cements, Steam Traps, Insulating Cements, and Electrical Supplies.

JOHNS-MANVILLE INC., NEW YORK

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General

Well screens or strainers, constitute an important detail of many water supply systems. They are used in connection with driven wells, ending in sand or gravel, where, as the name implies, they are employed to prevent the entrance of sand into the pumping system. They often provide the most practical and economical means of securing the full capacity of wells or even of increasing their capacity, besides being the means of avoiding the ill effects of sand in wells and pumps. The extent to which they are needed depends upon the character of the water bearing stratum and the quantity of water required. If the formation is of loose texture containing or consisting of fine material, and the velocity of the current is sufficient obviously the conditions exist which tend to the pumping of sand. The function of a screen lies in holding back the coarse material while the well is vigorously pumped and surged to remove the fine.

Brass Screen

Edward E. Johnson, Inc., St. Paul, Minn., has specialized in the manufacture of well screens for over 16 years. Its products include two types of screens, the Johnson Brass Screen and the Johnson Pipe Base Screen, and a complete line of accessories. The two types of screens are built in various sizes, and, together are adapted for all kinds of well screen installations and service. They are in operation in the plants of many of the largest railroads, municipalities, and industrial concerns of the country.

Brass Well Screens

The company's best known product is its Brass Well Screens. These screens are made entirely of brass. They also embody several other desirable features, among which are an extraordinarily large inlet area, and a durable and non-clogging inlet slot. The screen is a cylinder made up of the coils of a single strip of brass of special section, the successive coils of which interlock. The brass strip is so constructed that a narrow slit occurs on the outer face of the cylinder between successive coils, which runs continuously in a spiral from one end of the cylinder to the other. The water passes through the slit into an interior annular space provided by the construction, the sides of which diverge sharply inward from the slit to prevent clogging, and thence the water passes through large oval openings, provided in the inner wall of the cylinder, to the well. The brass is of special composition and treatment to afford adequate strength, and to give the inlet slot the desired resistance against the wear of sand. The inside or supporting wall, although strong in itself, is reinforced by brass rods soldered continuously to the inside wall. The screens are made in sections from 2 ft. to 16 ft. in length, for setting in pipe from 2 in. to 18 in. in diam., and with inlet slots from 0.006 to .060 in. in width. In all cases the length of screen and the width of inlet slots should be determined from the amount of water required and the fineness of the sand, respectively. The screens are adapted for setting in wells by pulling back the casing, washing down, or bailing, but they are not intended for driving. For small installations a special adaptation of this screen is made, consisting of a screen 30 in. to 60 in. long fixed to a 1¼ in. threaded galvanized pipe and flush point for setting through 2-in. well casing.

Pipe Base Well Screen

The Johnson Pipe Base Well Screen is designed particularly to meet conditions which necessitate the driving of the screen ahead of the casing. This type of screen has been on the market for five years, during which period it has received much favorable attention. The screen consists of an iron pipe, perforated and threaded, the perforated section being covered with a continuous spiral wrapping of Johnson Jacket Ribbon soldered to the pipe and having upon this in open spiral a tinned solderstrip wound in the opposite direction for reinforcing. The jacket ribbon is made up of parallel strands of triangular brass wire soldered crossways at regular intervals to maintain the slot intervals. The ribbon is one inch wide and is furnished in .010, 0.015, .020, 0.028, .036, and 0.048 in. slots. The ribbon is applied to the pipe with the apex of each triangular section against the metal to secure firm contact and to provide an inlet with sides diverging inwardly to prevent clogging. The screens are made in sizes to fit into wells from 2 in. to 18 in. in diam., and except for the 2 in. and 2½ in. sizes will carry their couplings through the well casing.

Pipe Base Screen

This type of strainer can often be employed to distinct advantage for the reason that the screen can be removed, cleaned of its coating of mineral matter, and replaced, or a new screen surface applied. For this purpose and also for concerns which perforate their own pipe, the company furnishes winding tools and Jacket Ribbon.

EDWARD E. JOHNSON, INC., ST. PAUL, MINN.

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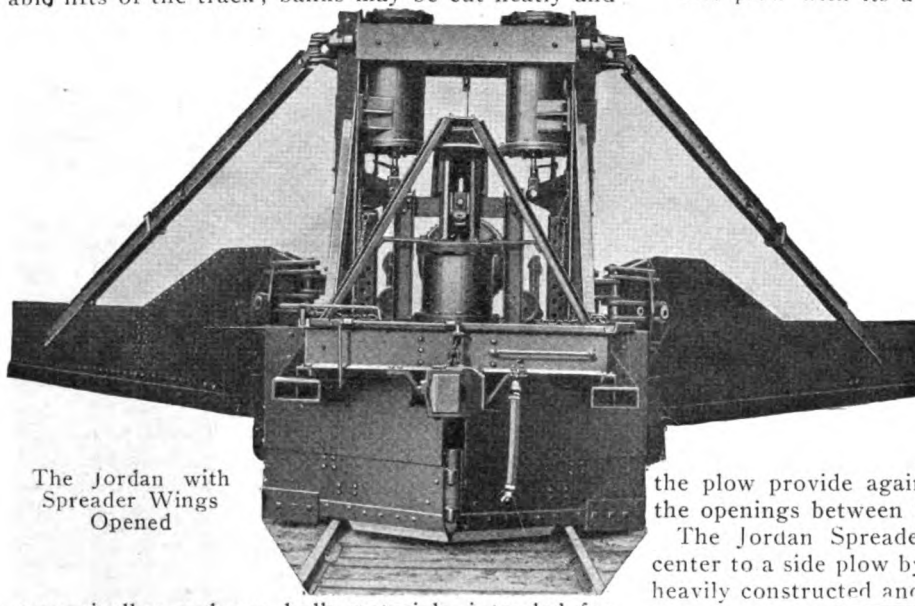
SPREADER, DITCHING AND BANK SLOPING ATTACHMENTS

General

A spreader is indispensable for the expeditious leveling of loose materials which have been unloaded in the ordinary course of repairs, or deposited for storage or as waste. The Jordan Spreader is not only efficient in the routine conduct of maintenance work, but by virtue of the attachments added, has had the scope of its performance widened until today it has become necessary equipment, both on the railroad and in many private industries, for a large variety of work.

The Jordan Spreader is used for moving, leveling and spreading clay, sand, rock, slag, debris, coal, coke and ore. It is regularly employed in the winter for plowing snow and ice from main tracks, sidings and yards, this duty including also removal of snow from between the tracks. A grade for a new track may be made economically with the Jordan; or banks may be widened; or ballast may be leveled to a safe distance below the rails.

High banks can be cast up with the Jordan Spreader to supply the material for making considerable lifts of the track; banks may be cut neatly and economically; and any bulk materials, intended for storage, or waste materials for filling purposes, can be kept within a limited space by leveling them with the Jordan Spreader, the track being raised from time to time as may be required.



The Jordan with Spreader Wings Opened

The effectiveness of the Jordan Spreader in performing many of the grading operations in maintenance is so well recognized that the slogan, "Does the work of an army of men," as applied to this device, is not merely an expression, but a definite truth. It has been estimated that in spreading dirt, in handling snow and ice, or in many similar items of work, the performance of the Jordan will equal that of 2500 men.

The routine maintenance work of cleaning old ditches, making new ones, leveling ballast dumped for the purpose of raising tracks, and keeping the ditches free from grass and weeds, has been regularly done by the use of the Jordan, effecting enormous economies over the hand method. In ditching operations the labor is reduced to that of the one man operating the machine and the neatness of the finished ditch far surpasses that where made by hand. This is rendered possible by the addition of the ditching and bank sloping attachments, which permit of making new ditch under favorable conditions at a speed of 2½ miles per hour and a cost of $3 per mile.

The Jordan Spreader is manufactured by the O. F. Jordan Company, office and works at East Chicago, Ind.

The Improved Jordan Spreader

The Jordan Spreader, which is built entirely of steel, is well known on all railroads, but with recent improvements is more useful than ever. Steel castings have replaced iron castings, reducing repair bills to a minimum, and the machine has been greatly strengthened throughout, including the addition of cast steel cutting edges to the front plow and big wing. The standard Jordan will cut at any point from 20 in. above the rail to 20 in. below, spreading all material to a point 21 ft. 6 in. from the center line of track, if desired.

The plow with its attachments is raised and lowered by means of a 16-in. cylinder and can be adjusted to cut from 7 in. above, to 2 in. below, the top of the rail, or if desired to a level close to the tie. Manganese castings riveted to the lower edge of the plow directly over the rail resist abrasion, while the heavy steel castings which form the cutting edge at the nose will displace all materials that may be encountered, even solid ice. Small wings at the rear end of the plow provide against materials passing through the openings between the plow and the wings.

The Jordan Spreader may be converted from a center to a side plow by means of an extension plow, heavily constructed and well braced, which is hinged to the nose of the center plow. This attachment,

The Jordan with Side Plow in Use

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which can be used on either side, gathers all material that is within 3 ft. 6 in. of the rail, carries it across the track and leaves it in position to be spread by one or the other of the main wings. The latter are made strong enough to withstand any uniform load caused by the displacement of materials when two locomotives of the Sante Fe type are attached. The wings are raised and lowered by means of two 17½-in. air cylinders placed on the upright posts.

The braces between the car body and the main wings are jointed in such a manner as to fold against the side of the car, drawing the wings in with them. This is accomplished by means of two 16-in. air cylinders placed underneath the car. The joints in these braces are of heavy cast steel and are so arranged that the greater the pressure against the wings the more firmly they are held in place. An air receiver 4 ft. 3 in. in diameter by 6 ft. in length is provided on the spreader. An air gage, air whistle, and the seven air valves necessary, are placed close together, so that one man can handle and operate the entire machine from one place on the car.

Work Done by the Jordan

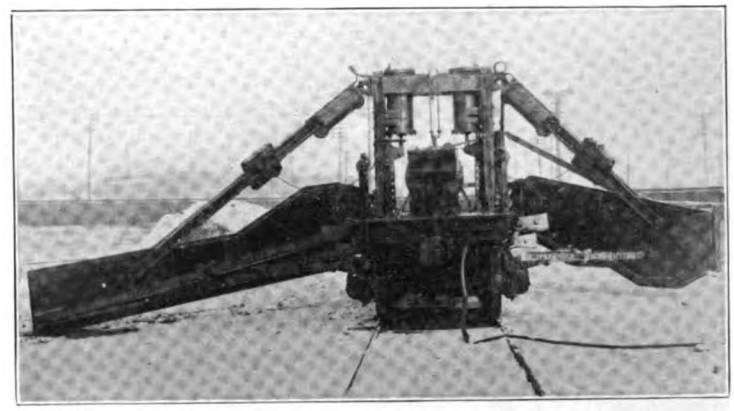
In plowing off snow, the plow is lowered to the rails and one or both of the large wings opened up, as the case may require. With both wings in use the snow can be carried from the center of the track each way to as wide a distance as 21 ft., making the total width of the cut 42 ft. The flanger blades on the lower edge of the plow flange cut either snow or ice to the depth determined upon. The flanger will even cut solid ice from the whole width of the gage, so that supplemental work will not be necessary. This is possible because of the position of the flanger which is immediately ahead of the forward truck.

In making grades or widening banks, one or both of the large wings are opened to the width required, and the material is spread when the car is pushed ahead by the locomotive. The grade can be cut on a gradual slope to allow for drainage from the track.

In the laying of parallel adjacent tracks, after the

Flanging Solid Ice

ballast has been deposited it is spread by means of one of the large wings to a depth of 2 in. below the bottom of the ties, when the track can be laid, reballasted, and then raised to the final height. For building high banks, as in grade elevation, a special set of braces may be supplied to be used against the wings in a way to permit free operation in opening and closing them. They may be applied easily and will elevate the material to the desired height above the rail.



Rear View Showing Bank Sloping and Ditching Attachment

Bank Sloping Devices

The addition of these devices, which are telescopic braces controlled by air cylinders, supporting the outer end of the spreading wing, thereby allowing the outer end of the wing to be dropped 39 in. lower than the inner end of the same. This makes it possible to cut 5 ft. below the top of the rail, at 21 ft. from the center line of track and leaving a slope 39 in. from the end of tie to the outer edge of cut.

The Ditching Device

This is a wing built especially to cut the true standard cross-section of any road purchasing it. This attachment will trim ballast, shape the subgrade, form the ditch, down to a maximum depth of 4 ft. 4 in. below the top of rail. And through its adjustability it will carry from 8 yds. of sandy, gravelly material to 20 yds. of wet, semi-fluid muck through cuts to where it can be wasted on a fill or trestle or left in large piles at predetermined points, where it can be loaded into cars by steam shovels or any other method desired. In case hauls to where material can be wasted do not average more than 1,500 to 2,000 ft., it will be much more economical to use the Jordan. Work of this kind can be done for ten cents per cubic yd. But where the banks are wide enough that materials can be spread beyond the ditch bank—say 21 ft. from the center line of track, and these banks are not more than 3 ft. above the top of the rail, ballast can be trimmed, subgrade shaped, ditch formed and all excavated material pushed beyond a point 21 ft. from the center line of track at the rate of not less than 1,000 cubic yds. per hour. These figures are facts; they can be substantiated from the records of several railroads using the improved Jordan with Ditching Attachment. When a ditch is formed by a Jordan the grade at the bottom is just as true as it is at the top of rail.

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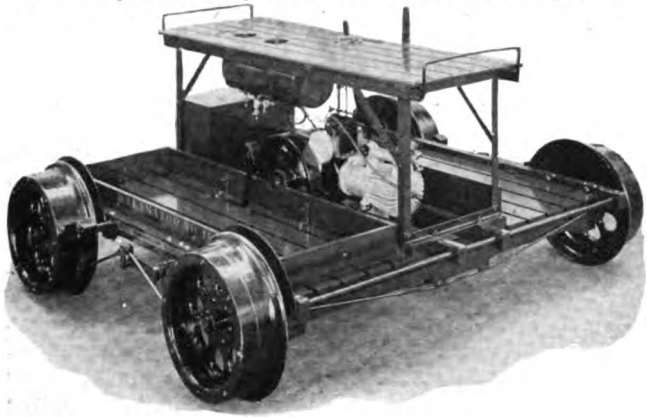
General

The Kalamazoo Railway Supply Company, Kalamazoo, Mich., has been for more than 30 years a builder of railway maintenance equipment. This long experience has enabled the company to offer designs which have been proved efficient through many years of successful use, and to supply materials that are of time-tested quality, well calculated to afford a durable service. Its complete line includes motor, hand, push, rail and velocipede cars of both wood and steel frame; track drills, gages, levels and the Jackson electric tie tamper; and cattle guards of wood and steel construction.

The Kalamazoo line of motor cars is the result of over 20 years' study and trial in the devising of a



Kalamazoo No. 16 Motor Car

car capable of performing full duty in the handling of section transportation. The cars were developed after a careful survey of railway conditions, the suggestions of practical railway men being embodied in their design. These cars are built in a number of different sizes and kinds which permit of a selection to meet all conditions of use.

The "Jackson" Electric Tie Tamper is a new tool recently brought out by this company which is constructed on logical lines to make it available for rapid tie tamping with a minimum of physical exertion and with only ordinary mental effort on the part of the operator. It is a potential means of defeating the handicap of the shortage and inefficiency of labor confronting the railways today. Its use will solve many of the difficult problems of track maintenance.

The line of track tools includes the Moore track drills, which are designed for heavy and severe work in the drilling of rails, and have the feature of a detachable upright that may be removed instantly to allow the passage of trains without disturbing the drill. The other tools include several patterns of levels and gages. The company also manufactures a number of special track appliances, among which are cattle guards.

Kalamazoo No. 16 Motor Car

With the present labor situation constituting a severe handicap to production it is essential that labor-saving devices shall be employed to the fullest extent. The place of the motor car in this category has been established through its widespread use, and it has now become standard equipment on many roads. The need of a car which may be handled by one man in putting it on and off the track and yet may comfortably seat as many as four persons on occasion has been met in the Kalamazoo No. 16 Motor Car which is called the "Safety First" One-man Car.

This car uses through running axles and four wheels of equal diameter, has motor and seat in the center of the track and a brake which acts on all four wheels. It is provided with magneto ignition and free engine clutch, so that the motor can be started by cranking, obviating the danger of personal injury from running along with the car. A recent improvement is the step-starting device by which the engine can be started by a thrusting with the foot on the starting pedal.

The motor was designed specially for this car and responds readily to the throttle. Being geared down to the drive axle, greater power is available than with direct connected motors of larger size. The new large magneto is driven by enclosed gears and the multiple disc clutch permits the motor to run idle when the car is standing or to start under load and climb heavy grades without waste of power. A kerosene attachment can be supplied if desired.

The car is built as light as possible consistent with strength, only selected white ash being used for the deck and seat. A large tool tray is provided in addition to a closed box beneath the seat for smaller tools. This car, like all Kalamazoo cars, runs on Hyatt roller bearings. The car can be operated safely on curves and over switches and crossings at permissible speeds and will run with the same degree of safety in either direction. Weight 400 lb.

Kalamazoo No. 17 Section Motor Car

For ordinary section work, where a gang of not over eight men and tools are to be carried, the Kalamazoo No. 17 has proved itself useful equipment. It is simple in construction and operation and has ample power to handle ordinary loads. The motor starts by rocking the flywheel against compression, runs equally well in either direction, and the car is light enough to be easily removed from the rails by two men.

The engine of the Kalamazoo No. 17 is a single

Kalamazoo No. 17 Section Car

cylinder two-cycle air-cooled 5 hp. motor with 4 in. bore and 5 in. stroke. It has battery ignition and the lubrication is by oil mixed with the fuel. This type of motor has few working parts to get out of adjustment. It is a free running engine with balanced double fly wheel construction, making it practically free from vibration. The motor unit is com-

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plete in itself, including fuel tank, spark and throttle controls. The drive is through a heavy roller chain from the engine sprocket to an internal expanding clutch on the axle which is operated by a hand lever. The car runs on 20-in. Kalamazoo steel wheels in Hyatt roller bearings and has a powerful lever-operated toggle brake applied to all four wheels. The body is 6 ft. long by 4 ft. 6 in. wide and the car weighs 850 lb.

Kalamazoo No. 19 Section Car

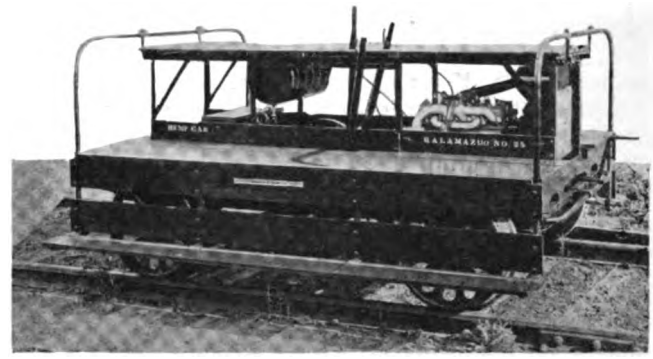
The tendency in recent years has been to extend the scope of the sections, creating larger units of labor force which have greater efficiency in renewals, the longer distances to be covered requiring the use of motor cars. For the section or extra gang of not over 12 men the Kalamazoo No. 19 Motor Car has advantages which make the car a useful one in maintenance or construction.

Kalamazoo No. 19 Motor Car

The car has an 8 to 10 hp., two-cylinder, horizontal opposed air-cooled motor, standard Kalamazoo friction transmission and Hyatt roller bearings throughout. The necessary room is afforded by the deck extending over the wheels. The motor starts by cranking and the car runs with equal facility in either direction. A powerful brake is applied to all four wheels. The weight of this car is 850 lb.

Kalamazoo No. 25 Motor Car

This car is one of the most powerful cars for its purpose yet produced. It is capable of continuous operation at work for which the so-called section cars have been found unsuited. It has, in the standard body, seating capacity for 12 men, and with the Hump body, which has foot boards, 12 more men can be accommodated, making a total of 24. There are a large number of body styles which

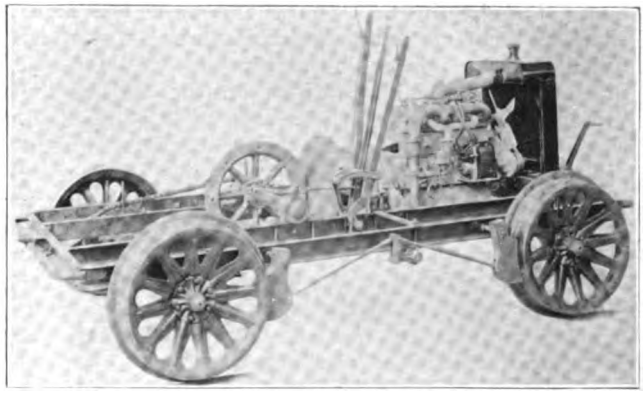


No. 25 Hump Car

can be used with the standard power unit and transmission, permitting section cars, semi-freight carrying cars for terminal use, cars for hump yard service, inclosed inspection cars, passenger cars seating up to 22 people for feeders and slow moving tractors for hauling loaded trailers, to be readily handled. The standard No. 25 has a weight of 1510 lb., shipping weight about 1600 lb. and it is equipped with a 20 to 25 hp. four-cylinder, four-cycle, water-cooled motor with large radiator, using thermo-syphon cooling. Transmission is the friction disc type, all shafts being hardened and running on Hyatt roller bearings. Axles are mounted on Hyatt roller bearings, with spring boxes if desired. Each wheel has a ball thrust bearing at the hub to take the thrust at curves and switches. The heavy duty friction disc drive permits

Standard No. 25 Motor Car

a full range of speeds in either direction. The car is built with a heavy channel frame, riveted and welded to give maximum strength. The speed has a large variation from 2 to 35 miles per hour. The standard car has a length of 7 ft. 6 in. with a width of 5 ft. 6 in. All cars are supplied with a speed governor which can be so set by an authorized party that the motor cannot exceed a predetermined speed. The car is provided with tow iron at the rear for attaching trailers, which can be furnished for passenger or freight service. This car has been used readily for moving large gangs of men from place to place, using the hump car body and hauling two trailers with a total of 75 men.



Chassis No. 25 Motor Car

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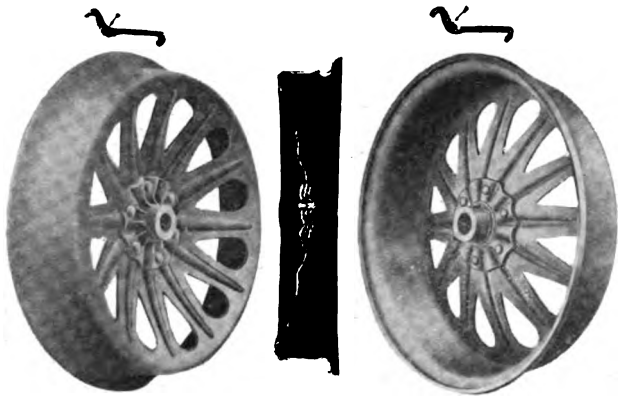
Kalamazoo Velocipede Cars

The velocipede car is handy equipment where one to three persons are required to travel long distances in routine work, such as that of the supervisor, signal repairman, lampman and others. The Kalamazoo Velocipede Cars are of wood or steel frame construction, the former being equipped with the Kalamazoo wood center wheels, the latter with pressed steel wheels. The No. 12 wood frame construction car is equipped with the Kalamazoo wood center wheels, ball bearings with hardened axles. The No. 12 Velocipede Car is intended for one man, the No. 13 for two, one operating, and the No. 14 for two, both operating, with the added feature of a tray for carrying tools and supplies. The No. 15 Wood Frame Car accommodates two persons, one or both propelling.

Kalamazoo Hand and Push Cars

There are many roads which have not adopted the motor car and upon which the hand car furnishes the only means of transportation over the section. Push cars will of course always be a necessary section equipment. Kalamazoo standard hand cars have been developed during the past 30 years to meet the exacting conditions of today. The greatest item of maintenance on a hand or push car is the wheel which in most cases wears out at the point where the flange and tread are joined. The Kalamazoo improved reinforced pressed steel wheel has been designed with surplus metal at the flange which affords largely increased life.



Kalamazoo Reinforced Pressed Steel Wheel

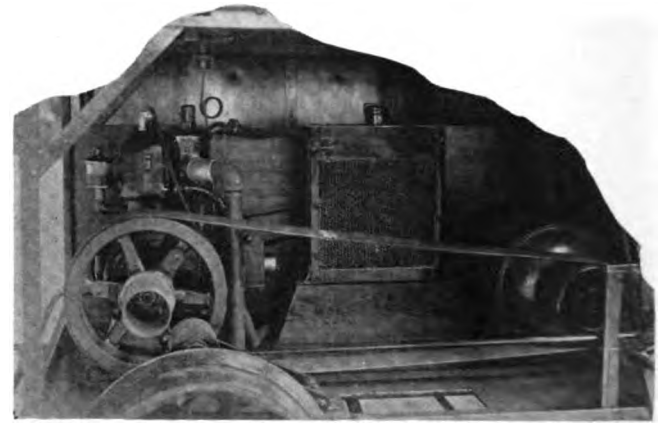
The Kalamazoo hand cars are high grade throughout and embody all the desirable features named. The standard No. 1 Hand Car has a platform 6 ft. long and 4 ft. 4 in. wide with axles 1½ in. in diameter and 20-in. wheels and weighs 510 lb. Hyatt roller bearings as well as insulation are furnished extra. The No. 2 Extra Gang Car is 1 ft. 6 in. longer than the No. 1 car and has longitudinal seats, the No. 2½ being similar but without side seats. The weight of the No. 2 is 625 lb., of the No. 2½ 735 lb. The No. 3 Standard Bridge Gang Hand Car is 8 ft. long and 5 ft. 8 in. wide. Modifications of these are furnished for inspection and other uses.

Kalamazoo No. 16 push car has 1½ in. axles, platform 7 ft. by 5 ft. 8 in. wide—weight 475 lb. No. 16½ is somewhat heavier than the No. 16, platform 7 ft. by 5 ft. 8 in. wide with 2-in. axles—weight 700 lb.

No. 8 and 8½ Rail cars for use of track layers, are equipped with chilled tread wheels, heavy axles and bearings, weights 1450 lb. and 1620 lb. respectively with capacity from 10 to 12 tons. The No. 8½ has extra wide wheels for track not yet brought to gauge.

The Jackson Tie Tamper

The mechanical tamping of track is an outgrowth of the necessity for labor-saving devices in maintenance and for a better grade of surfacing work than would otherwise be possible with present labor. On many economically maintained roads the surfacing of the track formerly amounted to as much as one-half the total labor



Electric Generator Unit for Tie Tamper

expense. The Jackson Electric Tie Tamper has been developed after two years of exhaustive study and experiment to reduce this heavy expense, notwithstanding the lower efficiency of the labor available. The tamper is a device weighing, for the standard pattern, 40 lb. and consists of a special enclosed dust-and-water proof electric motor to which is securely clamped the tamping bar and handle.

The motor is of the induction type, operating on 110-volt, 3-phase, 60-cycle circuits, and is of rugged construction. This type was adopted as being more suitable for operation by unskilled workmen, since brushes, springs and light or delicate parts, requiring adjustment or frequent renewal, are eliminated. The only attention necessary with this alternating current motor is lubrication of two bearings once a month. The rotor, or revolving element, is mounted upon a heavy nickel-steel shaft provided with two heavy ball bearings. Upon the end of the rotor shaft, next to the tamping bar, is mounted a steel unbalancing weight, which revolves at 3,600 r. p. m., producing powerful vibrations on the end of the motor casing to which the tamping bar is clamped. The forces set in motion by this unbalancing weight are transmitted through the tamping bar, forcing the ballast beneath the tie and in a downward and backward direction behind the bar, compacting the ballast as well as tamping the track. The force of the blow is proportional to the weight of the unbalancing member, which in the standard design is made suitable for tamping in rock or gravel ballast, but any special conditions can be met.

The Tamper has a wood handle so fastened by flat steel springs to both ends of the rotor as to absorb all

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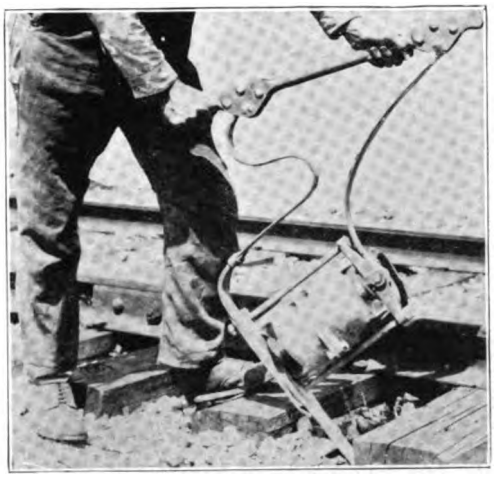
vibration and yet give perfect control of the tamping bar. The tamping bar itself is a comparatively short and heavily constructed iron bar, the end of which has been forged to the proper size. The tamper can be operated at a distance of several hundred feet from the source of power.

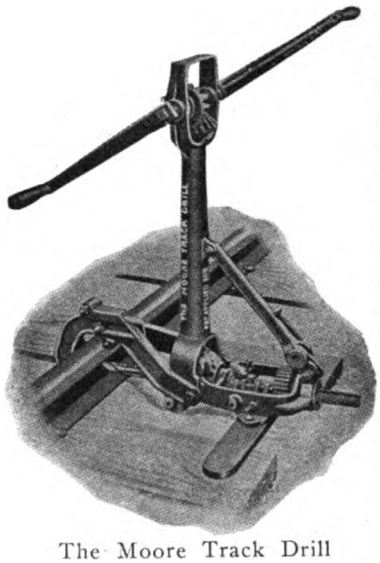


Jackson Tie Tamper at Work

The complete tamper plant consists of the required number of tampers with suitable electric generator and the engine which forms the prime mover. Many light-weight portable outfits may be assembled.

Moore Track Drills Nos. 1, 2 and 3

The introduction of heavier rail sections, employing a larger diameter of bolt, and the occurrence of both high and low carbom steels in track, has made necessary a rail drill with an automatic and variable feed adjustment which may be changed instantly. The heavy duty frequently entailed requires the use of a drill specially designed for this service. The Moore Track Drills, Nos. 1, 2 and 3, are built along entirely original lines which make for efficiency and economy in the drilling of every kind of rail, with large or small drill bits. These drills are high grade and designed to afford satisfactory service.



The Moore Track Drill

The operation of detaching the upright to let cars pass over the drill is accomplished quickly merely by shifting the eccentric lever in the back brace. When thus separated into two parts the drill becomes of such a compass that it may conveniently be stored away in transporting it on trains, and it can also be more readily carried about by the operator. The drill has an adjustable rail hook that goes over the top of the rail and is quickly placed and secured. It can be quickly adjusted for all conditions.

Any of these drills can be fitted with underclutch, or with hooks for girder and high tee rails, or for I beams. The drills can be fitted with the Kalamazoo combination self-centering drill bit chuck, which holds the drill tightly and true to center and will take all classes of high-speed steel flat shank bits and all sizes of flat and twist drill bits with round shanks 41/64 in. diameter. There is also an arrangement for operating the spindle independently of the feed to return it from or advance it to the rail. Kalamazoo No. 5 bonding drill has been redesigned so that the drill can be quickly and rigidly clamped to the rail. The feed and drill mechanism remain as before.

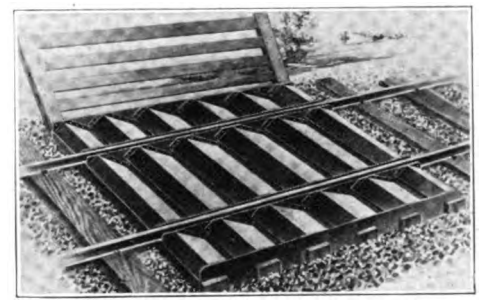
Track Gauge and Level

The Company has in the past few years put out a large quantity of its Improved Track gauge and level for engineers and track supervisors. It consists of a track gauge with guard rail attachment with scale, also master gauge which enables men carrying it to test all gauges that may be encountered in service.

Wood and Steel Surface Cattle Guard

The cattle guard, as its name implies, is a barrier designed to prevent the passage of stock along the track. It is a necessary provision in grazing country and its use is required by law in some states. The surface type of guard is used nearly universally, the pit type being seldom seen. The Kalamazoo Railway Supply Company makes two types of surface guards, the No. 15 Wood and the Kalamazoo "Perfect" Steel Cattle Guard.

The "Perfect" Steel Cattle Guard is designed not merely to discourage stock from advancing along



The "Perfect" Steel Cattle Guard

the track but to make it impossible for them to do so. Animals will slide toe first against the slot at the bottom of the guard and are unable to go forward, while they are free to withdraw the foot to go back. The guard consists of three separate sections ready to be fastened upon the ties which are already in the track. It is made as nearly rust-proof as possible by being dipped in an asphaltum bath. The guards are made in standard lengths of 9 ft.

The No. 15 Wood Cattle Guard is made of strictly northern-grown white oak, a dense tough wood, well seasoned, and is often preferred to the steel guard by reason of its durability. It is not subject to corrosion like the metal guards and, not being in contact with earth, is not exposed to decay. The sections are connected rigidly by means of steel rods and cast iron spacing spools, offering no chance for the guards to become racked out of shape by the vibration of the track. The guards are furnished in lengths of 8 ft., but any other length or modification of the design can be supplied.

Full details and particulars on the products illustrated above will be gladly furnished on application.

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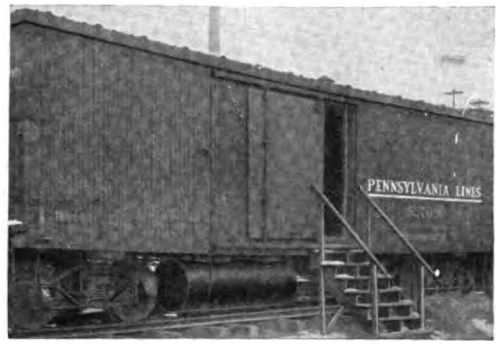
General

The Kaustine Company, Inc., Buffalo, N. Y., devotes its entire attention to the manufacture of the Kaustine Chemical Toilet systems and Hydro-Kaustine septic tanks, which are coming into extensive use at camps, stations and shops on the railroads of the United States and other countries. The company is organized to design and install the Kaustine systems as well as to manufacture them. Factories and assembling plants are located at Perry, N. Y.; Toronto, Ont.; and Melbourne, Aust.; and railway sales offices are maintained in New York City; Pittsburgh, Pa.; Chicago; Spokane, Wash.; Toronto, Ont.; and Melbourne, Australia. The factories are modern in design and



Kaustine Installation Ry. Outfit Car

equipment and offer facilities for handling work economically and promptly. An engineering service department is maintained to assist prospective buyers in the solution of problems involving the installation or operation of these systems.

Kaustine Systems

The Kaustine systems were developed to meet the need for the satisfactory handling of body wastes in districts or buildings not served by sewers. The need of equipment of this kind is being realized to an increasing degree by the railroads in common with other large employers of labor who are giving closer attention to the provision of more attractive conditions in their shops, labor camps, etc., prompted frequently by the refusal of public authorities to countenance unsanitary conditions, but due largely to the influence that improvements of this character bear on the holding of men.

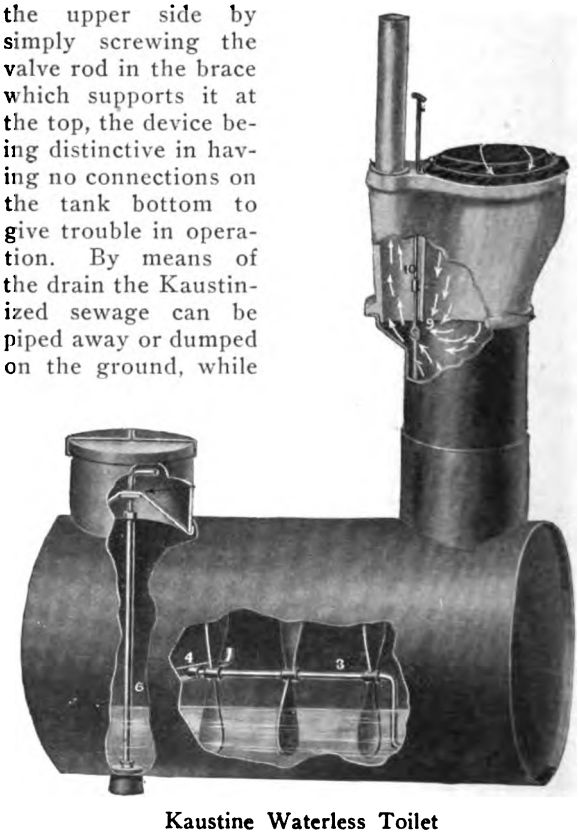
The adaptability of the Kaustine systems to the problems encountered on a railroad has been amply demonstrated, many of the leading railroads employing them in their shops, labor camps, depots, signal towers, outfit cars, etc. The systems are based on the principles long advocated by health authorities of effecting the immediate segregation and purification of sewage, and offer an economical and effective means of avoiding the offensiveness and inconvenience of less modern methods. They have met with the approval of health authorities as well as the large variety of users and are guaranteed by the Kaustine Company to give satisfactory service. Owing in large part to their adaptability to household and industrial sanitation problems and to the character of service shown by typical cases, over 60,000 installations have been made since the establishment of the company in 1912, many industries having gone so far as to equip entire villages.

Kaustine Waterless Toilets

The Kaustine Company is known to the railroads particularly for its waterless systems. These systems are intended for use in buildings where physical difficulties or high cost make it impracticable to connect with a sewer or install a septic system. They operate by a process of chemical action and ventilation. The design of the Kaustine system is such that, above the floor, it has the general appearance of a water-operated system. The bowl, however, is attached to a cylindrical iron tank suspended below the floor or embedded in the ground, in which is kept a solution of Kaustine, a powerful chemical, which acts immediately upon matter reaching the tank, completely disinfecting it and reducing it to a state in which it is powerless to create a nuisance and can be pumped or drained away without difficulty.

Each tank is equipped with a rotary agitator, drain valve, and ventilating system. The agitator consists of a horizontal shaft supported in the center of the tank, upon which propeller blades are carried. One end of the shaft is bent into a crank and is connected to a rod extending upward through the drop tube of the tank to a point above the seat, the agitator being set in motion without difficulty by pushing on the rod. The agitator performs the three-fold function of keeping the chemical well mixed, insuring complete chemical action, and preventing clogging of the drains.

The drain valve fits into a hole in the bottom of the tank near one end and is opened or closed from the upper side by simply screwing the valve rod in the brace which supports it at the top, the device being distinctive in having no connections on the tank bottom to give trouble in operation. By means of the drain the Kaustinized sewage can be piped away or dumped on the ground, while



Kaustine Waterless Toilet

the tanks themselves require emptying only at infrequent periods. Where drainage facilities are not

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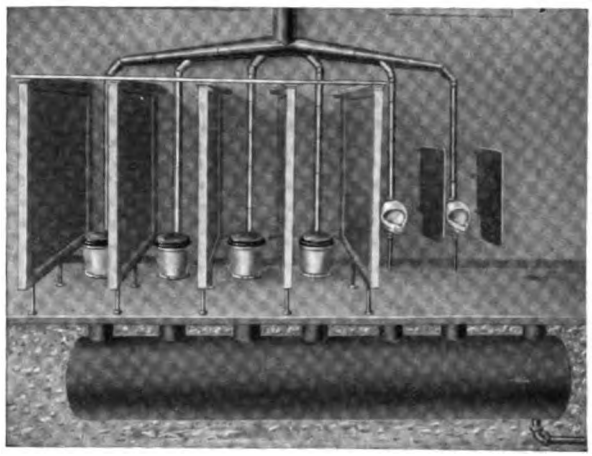
available the sewage can be removed without annoyance through the manhole in the upper side of the tank by means of special hand-operated pumps.

The ventilating system consists of a partition in the back of the bowl and piping extending to the roof. The system employs the siphonic action of the air currents above the roof and the difference between the temperature, and therefore the weight, of the air inside and outside the ventilator pipes to lib-



Kaustine Waterless System in Multiple

erate the slight amount of ammonia gas generated by the chemical action in the tank to keep the bowl dry and to prevent gases reaching the room. In large installations where ventilation according to prescribed methods is difficult to secure the design can be modified to accommodate an electrically-operated exhaust fan.

The Kaustine bowls are designed to withstand rough usage, being of high grade vitreous earthenware of extra heavy construction. The tanks are made of No. 14 gage Armco Ingot iron, material which offers marked resistance to corrosion, and are coated inside and out with Hermastic enamel to insure the maximum life under adverse conditions. To afford adequate strength the tanks are cylindrical, and all seams are electrically welded. The ventilating pipes are of Armco iron, galvanized.

The Kaustine chemical comes in large crystals, is dustless, and can be handled without difficulty. It is non-combustible, odorless, and can be stored indefinitely without loss of strength. It is put up in standard packages of various sizes for charging the tanks, the cost of which will not exceed $3.50 per charge for each 125 gal. of tank capacity. On this basis the cost of operating toilets in shops may be estimated to run from 30 cents to 45 cents per person per year.

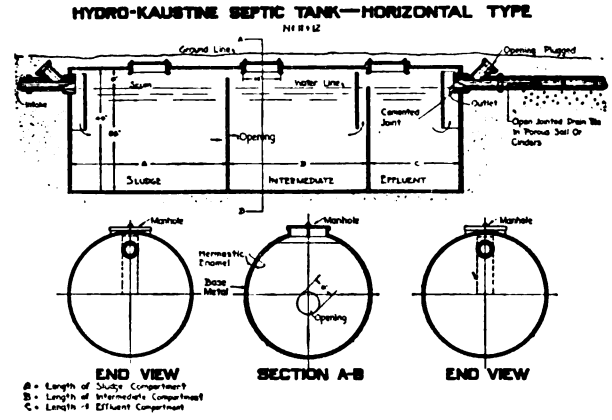
Kaustine waterless toilet systems are particularly adapted for large installations and are designed for arrangements in multiples of various combinations. When so arranged the ventilating pipes from each bowl or urinal terminate in a header and the header in turn is connected to the roof vent. For multiple systems the tanks are merely enlarged at the rate of 125 gal. for each bowl and can be constructed to accommodate batteries of six bowls. For these systems Armco iron partitions with or without doors can be furnished and all other equipment necessary to make the waterless system adequately attractive as well as effective.

The Kaustine Company also manufactures a portable waterless system. This consists of a shallow self-supporting cylindrical tank equipped with a vent and seat. The system is compact and can be transferred from place to place without difficulty.

Hydro-Kaustine Septic Tanks

The Hydro-Kaustine septic system is adapted for use where a plentiful supply of water is available and under such conditions affords a means of installing a toilet system similar in every respect to a sewer system excepting in the manner of disposal. The septic process of sewage disposal is one in which the sewage is purified by natural processes and is recognized by sanitary authorities as a satisfactory method when supplemented with proper facilities for completing the decomposition of the matter. In the process sewage is conveyed by water to a septic tank consisting of a number of properly-arranged compartments in which the matter is partially decomposed by bacteria. The residue collects in the tank bottom while the liquefied portion passes out of the tank and is distributed by porous tiling over beds where the combined action of air and other bacteria completes the decomposiiton. The system can be buried completely in the ground where the action can take place effectively, without requiring attention or creating a nuisance.

In the Septic system the Hydro-Kaustine septic tank is employed. These tanks are designed by specialists to meet adequately the requirements of a satisfactory septic system and are manufactured in types and sizes for all kinds of installations. As in the waterless toilet systems the Kaustine septic tanks are made of No. 14 gage Armco iron with carefully welded seams and are coated inside and out with Hermastic enamel. They are shipped complete, ready to set up, and require only the necessary earth



Hydro Kaustine Septic Tank Horizontal Type

excavation and connections with the pipe lines from the buildings and to the absorption beds for their use. Owing to the ease with which they can be handled and their moderate cost, the Kaustine septic tanks often afford distinct advantages in the construction of septic systems.

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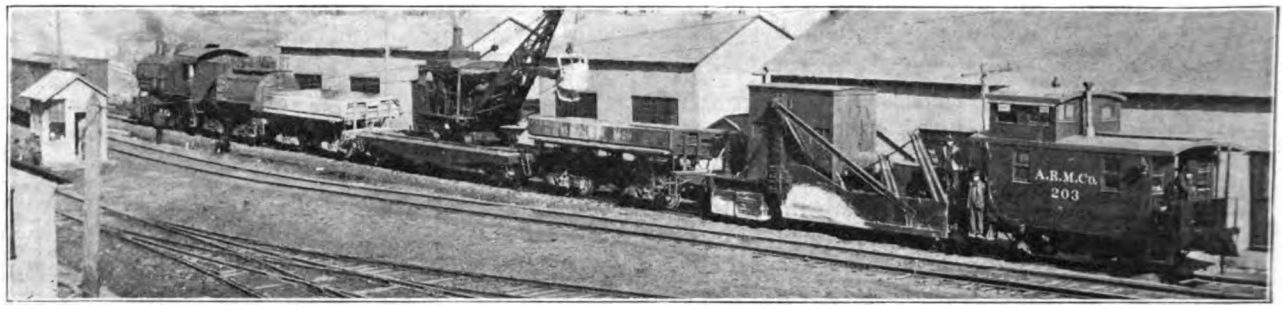
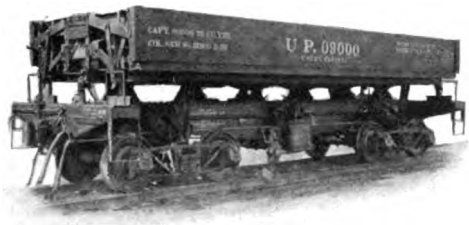


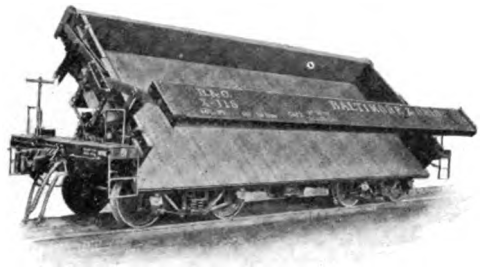
Two "K & J" All Steel Automatic Air Dump Cars in Train with Railroad Ditcher

General

The Kilbourne & Jacobs Manufacturing Co., Columbus, Ohio, is the originator and pioneer builder of automatic two way, side dumping air dump cars; automatically controlled air dump cars developed, designed, and built



20 cu. yd. "K & J" Dump Car, U. P. Ry.



"K & J" Car in Dump Position, B. & O. Ry.

by the company having been put into operation as early as 1908 as the property of the Carolina, Clinchfield, and Ohio Railroad near Johnson City in eastern Tennessee.

At the present time its cars are in use on over 50 of the leading railroads of the country and are serving more than 100,000 miles of track. They are widely employed also in iron and copper mines, and in various other industrial enterprises. In railway service they are regularly used for ditching, trestle filling, grade reducing, bank widening, rip-rapping, double tracking, hauling of track materials, and other maintenance work or emergency service and are of such design and construction as often to afford railroads with a practical means of effecting large economies.

The "K & J" Dump Cars

The "K & J" air dump cars are entirely automatic under all conditions. Operating air is drawn from a storage reservoir on each car. The reservoir is charged from the regular air brake train line and has a capacity sufficient to operate the loaded car two or more times independently of the locomotive. The operation of dumping a single car or any number of connected cars requires no more than 10 seconds. The complete operation, that of unlocking, dumping, and relocking, is accomplished by means of two simple levers, one for each side. When the car is in the dump position, the door is elevated in a plane parallel with the floor, thus giving full dumping clearance. Trains may be operated from any connected car, and cars may be dumped all to one side, alternate cars to opposite sides, or any connected section to one side and the remaining to the other.

The "K & J" cars conform to the practice recommended by the Master Car Builders Association and meet the requirements of the Interstate Commerce Commission. Those of interest to railroads are Model R-20 and Model C-16, having capacities of 20 and 16 cu. yd., respectively, when level full. They are made according to the following specifications:

	Model R-20	Model C-16
Capacity	80,000 lbs.	60,000 lbs.
Angle of dump	45 deg.	45 deg.
Length over couplers	32 ft. 0½ in.	30 ft. 0½ in.
Maximum width	10 ft. 2 in.	10 ft. 2 in.
Center to center of trucks	19 ft.	16 ft.
Top of rail to top of body	8 ft. 5½ in.	7 ft. 10½ in.
Approximate weight	49,000 lbs.	44,000 lbs.

A Train of "K & J" Cars Dumping Simultaneously on Bank Widening Work, L. & N. Ry.

KILBOURNE & JACOBS MANUFACTURING CO., COLUMBUS, OHIO

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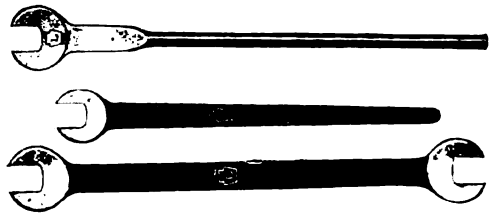
General

The Lakeside Forge Company, Erie, Pa., is a manufacturer of drop forgings of steel, iron, bronze and copper. Its principal product, drop forged wrenches, are manufactured in a wide variety of patterns adapting them to every railroad service. The track wrenches, made in both standard and special designs, are the ones most directly applicable to maintenance.

The plant of the Lakeside Forge Company is likewise at Erie, and has recently been entirely remodeled. The forge shop has been equipped with new



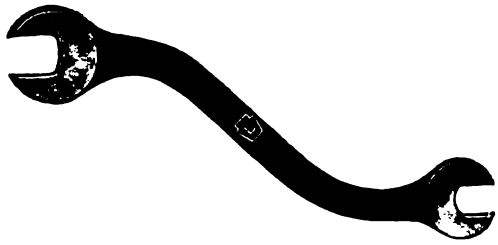
Track Wrenches

hammers of the latest design. The finishing and die departments are specially fitted for the finishing of the forgings. The plant is provided with facilities for heat treating, and also does case hardening, oil hardening, annealing, etc., when desired. A feature of Lakeside service is the full guarantee of its products, any defective or imperfect goods being replaced immediately.

Wrenches

The necessity of keeping track bolts tight makes the track wrench one of the essential tools in maintenance. The serious personal injury which is liable to result when the jaw of a wrench breaks under a severe strain requires that the material, as well as the workmanship, shall be of the best. Drop forged wrenches have been shown by test and experience to have the requisite factor of safety for track service. In the other departments of railroad work the requirements of a substantial tool are almost equally insistent, and are fully met by Lakeside wrenches.

The line of wrenches made by the Lakeside Forge Company is of entirely new designs which have been carefully worked out in every detail. Because of their manufacture as drop forgings they are specially adapted for the hard usage common to railroad work. Finished wrenches are milled to size, case hardened all over, polished, and highly finished with bright heads lacquered. The various wrenches are also furnished semi-finished or unfinished when desired.

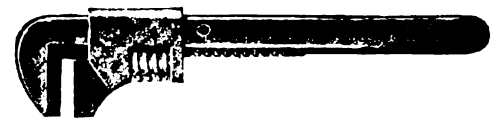


"S" Wrench

The track wrenches are made in whatever length of handle may be specified. The unfinished designs are broached and milled, the semi-finished designs being also case hardened. The openings are ⅛-in. larger than the distance across the flats of the nuts. The unfinished straight flat-handle wrenches are furnished single and double end, and are usually made 23 in. and 24 in. long.

The "general purpose" double-head wrench of 22½ deg. angle is a short handled wrench which is useful for running up the nuts preliminary to their final tightening with the standard wrench when relaying rail. The car wrench of the same general design, but with a long leverage, is preferred by some roads for a track wrench. The car wrench, with a jaw about 2 in. wide, may be used with a pipe extension for the opening and closing of hopper doors.

The entire line of Lakeside adjustable wrenches, which are of a design somewhat like the ordinary monkey wrench, is a handy equipment for general purposes. The 11-in. all-steel drop-forged wrench, which has the jaw as well as the handle drop forged, is a useful tool for work around frogs and switches. The crocodile wrench is an all-around handy wrench fitting any shaped nut, whether square, hexagon or round. The drop forged pliers in 6-in., 8-in. and 10-in. lengths are useful tools in the building of wire fences, and are specific equipment for the telegraph department.



Adjustable Wrench

Pliers

Special Work

Drop forgings are constantly being introduced into new fields of work and their sphere is amost unlimited. They can often be used in place of expensive machined parts. Their use is most general where strength, lightness and durability are required. The Lakeside Forge Company is equipped to make drop forgings to meet every reasonable requirement. The modern facilities at this plant assure the production of forgings that will give service. They are water or brush finished and are cleaned in a sulphuric acid bath, being afterward washed in potash and soda water to prevent rust.

The list of drop forgings which the Lakeside Forge Company is prepared to make includes a wide variety of parts required in current repairs to the tools and machines used on the railroad. They are manufactured from blue prints or models, and can be furnished to exact gage by restriking. A special new line is the drop-forged eye-bolts which are drop forged without weld from an extra quality of steel and are specially adapted to use on motors, pumps, etc.

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General

The Lehon Company, Chicago, is the manufacturer of a large line of protective products, including various composition roofings, building papers, water-proofing fabrics, roofing asphalts, and protective paints. The products are sold under the trade name of "Mule Hide." They have been on the market for 15 years and are widely used by the railroads.

Mule Hide Roll Roofings

Of the several roll roofings manufactured by the company the Mule Hide Smooth Finish Roofing is extensively used by railroads on freight and passenger stations, warehouses, labor camps, etc. This roofing is a heavy material, densely impregnated with a high melting point asphalt capable of withstanding the summer heat over long periods without losing its elasticity. As with all Mule Hide products, no coal tar is used in its manufacture. The roofing has a soap stone finish, and is made in medium, heavy, and extra heavy weights, weighing 40, 50, and 60 lb. per square, respectively.

Mule Hide Roll Roofing

Under the name of Mule Hide Slate-Kote Roofing the Lehon Company manufactures a roll roofing identical to the Smooth Finish Roofing, excepting in the finish. The Slate-Kote finish consists of crushed slate pressed into the asphalt while still warm to produce a surface which is highly resistant to the heat of burning embers as well as to the elements. This roofing is made in heavy and extra heavy weights, running 90 and 115 lb. per square, respectively, and in red and grey-green colors.

The Company also makes a Shingle Craft Roofing which is similar to the Slate-Kote Roofing, except in having a shingle pattern surface.

For uses where good quality roll roofing of a less expensive type is desired the Lehon Company manufactures the Tex-Tite Roofing. This roofing is adapted to any climate and is particularly adapted to installations in localities of comparatively mild weather and on work of a less permanent character. This roofing has a semi-smooth finish and is made in light, medium, and heavy weights running about 35, 45, and 55 lb. per square, respectively.

Shingles

The Lehon Company manufactures composition shingles in three different weights, grey-green and red colors, and in the individual and four-unit styles. They are of a tough fibrous structure, saturated with asphalt of high melting point, are heavily coated on the under side and finished with fine soap stone, and are not susceptible to curling up in service.

House Lining and Building Papers

For lining and sheathing walls of frame buildings against cold, drafts, or dampness, the Lehon Company makes three products. One of these, the Mule-Hide House Lining, is a felt saturated with asphalt. This product is an excellent insulator and is odorless. It is put up in rolls, weighing, respectively, 50 lb. and 28 lb. per roll.

The Seal-Skin and Black-Bear Waterproof Papers comprise other Lehon building papers. These papers have a hard finish and do not become soft or sticky from heat, or crack in cold weather. The Seal-Skin paper is put up in 500 sq. ft. rolls, 36 in. wide, weighing 45 lb. per roll. The Black-Bear is put up in 32 or 36-in. rolls, weighing, respectively, 30 lb. and 35 lb. per roll.

Mule Hide Waterproofing Fabrics

Of several fabrics manufactured by the Lehon Company for waterproofing and sheathing purposes, the Mule Hide Cotton Membrane, Saturated Burlap and Asphalt Felt are of chief interest to the railroads. Mule Hide Membrane is a cotton fabric impregnated with waterproofing and preserving compounds and of a tough elastic texture suitable for use in the waterproofing of bridges, parapet walls, tunnels, subways, etc., in this work being mopped on in alternate layers with hot asphalt.

The Saturated Burlap is simply a burlap prepared for the same use as the cotton membrane.

Mule Hide Asphalt Felt is a fibrated product impregnated with asphalt similarly to the Mule Hide Roofing. It is particularly adapted for use as the first layer of built-up roofs applied on either concrete or wooden decks and is also in general use for sheathing purposes. The material is put up in weights of about 15 and 22 lb. per 100 sq. ft. respectively.

The Company will furnish built-up roof specifications on request.

Mule Hide Asphalt

The asphalt of the Lehon Company is specially prepared for waterproofing purposes. It is the product of a blending of asphalts of the more expensive grades, and is capable of resisting injury from heat, cold, and moisture with equal facility. The material is put up in sealed metal drums of 50 gal. capacity and in gallon cans, and is regularly used for built-up roofs and in waterproofing tunnels, reservoirs, etc.

Other Products

Other products of the Lehon Company include lap cement and roof coating for application to composition roofs, waterproofing compounds for application to concrete, brick, stone, tile, etc., asphalt paints for the protection of screens and other metal surfaces exposed to weather, and flexible asbestos cement for flashing around skylights, ventilators, window sills, etc.

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FIR GUTTERS

General

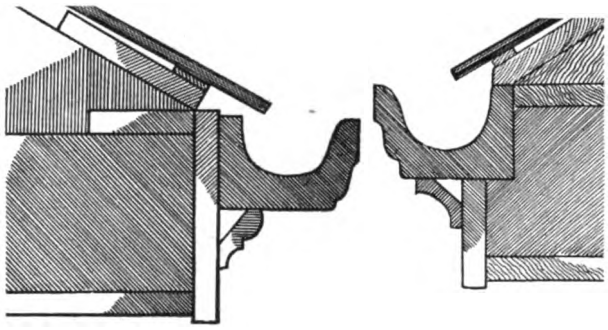
E. M. Long & Sons, Cadiz, Ohio, manufacturers and dealers in lumber, are known to the railroads particularly for their "Improved" O. G. Fir Gutters, developed to meet a need for equipment capable of rendering effective service economically over long periods under the severe conditions exisiting on depots, office, and

A. C. L. Passenger Station, St. Petersburg, Fla., Equipped with 5 in. x 7 in. O. G. Fir Gutters

other railway buildings throughout a large portion of this country and Canada. The success of the company during the 25 years of its existence in establishing a large and growing market for its gutters, is an indication of their merit. The plant at Cadiz is equipped to handle materials to the best advantage and is provided with excellent shipping facilities. When greater economy or speed in delivery are essential, orders are filled direct from a mill adjacent to the Douglas fir timber on the Pacific Coast. The products are also carried by jobbers in several cities.

Wood Gutters

In preventing roof run-off from staining the walls of imposing or costly structures, forming dangerous icicles, creating a nuisance in passageways or on walks, preventing seepage through casements or walls, scouring embankments or soil plots, or flooding basements, gutters are of sufficient importance to railroads to warrant their spending large sums annually in



Method of Applying O. G. Fir Gutters

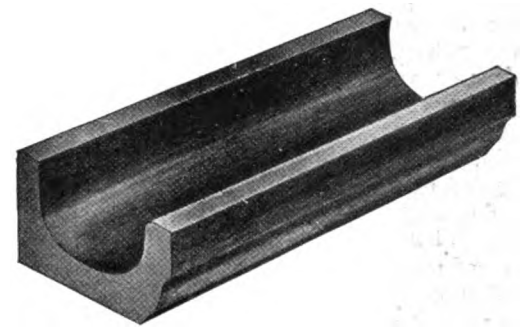
installations and repairs. The upkeep of gutter systems on railway buildings usually involves more than ordinary expense, owing to the small amount of attention given them and to the severe conditions common to railway structures because of the action of locomotive gases, and cinders.

Wood has been used for gutters since time immemorial. Those characteristics which adapt it for use in water tanks, flumes, boats, and similar types of construction subject to exposure and wetting also fit it for use in gutter construction. When well designed and of suitable material these gutters can be employed to distinct advantage. They are amply strong, easy to install, and are unaffected by corrosive agents common to railways.

"Improved" O. G. Fir Gutters

The "Improved" O. G. Fir Gutters are made from Douglas fir obtained from the State of Washington, a wood well known for its durability when exposed to weather and its adaptability for structural use. The fir used in their construction is obtained only from the choice cuts of the tree, is exceptionally low in pitch, is straight grained, thoroughly seasoned, and free from defects in material and workmanship.

The gutters are cut from 3x5, 4x6, and 5x7-in timber in lengths up to 40 ft. and weigh 150, 200, and 300 lb. per 100 lin. ft., respectively. Their design provides a large deep trough with adequate stock for the bottom and sides, and a neat mould on the outside face to match cornices. The bottom and



A Section of O. G. Fir Gutter

back of the gutters are flat to enable them to fit snugly to the building, the gutters being built into the roof as a part of the cornice, applied to the face of the boxing, or to the foot of rafters. Owing to the depth and smoothness of the trough the gutters require but a slight pitch and are frequently installed without any slope. Mitered joints are made at corners and square joints elsewhere, the joints being well leaded or treated with a wood preservative, strengthened when necessary by iron tongues driven into the ends, and supported on the under side by stair rail bolts or by the down spouts. The down spouts are attached by extending a metal connection through a hole in the trough and tacking its top flange to the trough bottom or by providing a smaller hole in the gutter and attaching the spout to the bottom of the gutter. The best practise recommends the installation of down spouts at all gutter joints.

The O. G. Gutters lend themselves readily to architectual treatment, are not expensive, can be installed by regular maintenance crews, and can be relied upon to give adequate service over unusually long periods at practically no expense, instances being on record where they have given 25 years of service without attention.

E. M. LONG & SONS, CADIZ, OHIO

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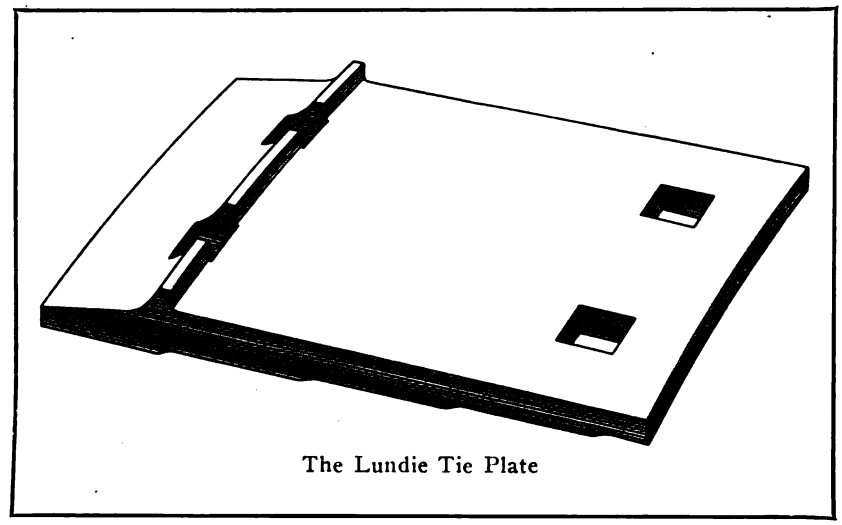
Development of the Lundie Tie Plate

The Lundie Tie Plate was developed by John Lundie, D. Sc., when actively engaged in charge of one of the railroads of the United States Steel Corporation. The problem presented was the development of a tie plate which should perform not only the function of preserving the tie, but should as far as possible be a safety-device and one which should give the rail fair treatment as a light beam carrying a heavy load, so as to increase the life of the rail in service. The Lundie Tie Plate when developed proved itself to be much more than a mere tie preserver. It minimized tendency to accident by opposing track spreading; it reduced internal stresses in the rail, so tending to reduce rail fracture; it has given in service an increased life to rail of over fifty per cent, according to actual railroad records; it has saved maintenance expense and conduced to safety, in holding the track rigidly to gauge; it has preserved the tie while holding the track to gauge, by not cutting a single fibre of the tie and by hardening and glazing the surface of the wood under the plate; it has promoted easy riding and does not rattle.



The Lundie Tie Plate

The Inclination

Rail inclination by itself is not a new development; it has been standard in European countries for many years, to conform with the angle of bevel or coning on the wheels; thus bringing the wheel load in the center of the head of the rail instead of near the edge of the rail. The inclination of rail in European countries and elsewhere has hitherto been effected by resting the base of the rail on an inclined chair or tie plate, which chair or tie plate has usually had a flat base parallel to the top of the ties, and it has been necessary to secure the chairs or tie plates by heavy bolts passing clear through the tie and clinched on the bottom thereof, in order to counteract, as far as possible, by such a method, the tendency of a flat bottomed wedge-shaped plate to slip outward under load. This tendency to slip outward is counteracted in the Lundie Tie Plate by making the bottom of the plate of such a form as to eliminate, instead of merely resisting, this tendency toward slipping, in so far as the thrust due to the coning of the wheels is concerned. This thrust on a coning of 1 in 20 is no small force, but amounts to 100 lb. per ton.

Wheel Coning

Periodically, some inexperienced man suggests the removal from the wheels of the coned or bevelled tread, forgetting that the coning of wheels had been developed by a hundred years of hard experience in railroading, and is an essential feature in the safe operation of all equipment. Indeed, the coning of wheels (while exerting a uniform lateral thrust on the rail which is counteracted by the Lundie plate through being eliminated, it having all bearing surfaces normal to the resultant thrust above mentioned) is instrumental in minimizing the effect of the impact of the lateral thrusts of unbalanced locomotives, the wheel flange pressure on curves, etc. On a coned or bevelled wheel, when a wheel flange approaches the rail, the tread of this wheel is running on a greater diameter than that of the opposite wheel on the same axle. Thus, the wheel flange swerves away from the rail until a corresponding action takes place on the opposite wheel. Were the treads of wheels flat, they would thrash irregularly from side to side between the rails and quickly destroy both equipment and track, not to mention the probability of a derailment.

The Base

The base of the Lundie Tie Plate consists of a number of seats, joined by gentle curves, somewhat similar to the steps of a stair; such seats being parallel to the upper surface of the plate. Thus, all bearing surfaces (the base of the rail, the top surface of the tie plate, the bottom surface of the tie plate, and the surface of the tie on which the plate rests) are at right angles to the resultant force of the wheel load, combined with the thrust of 100 lb. per ton caused by the coning of the wheels. Such resultant force being at right angles to all bearing surfaces, all tendency to slip on account of such force is eliminated. The action of the base of the Lundie plate is correctly and

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aptly illustrated by Fig. 1. In this diagram, the bearing of the wheel on the rail, tie plate and tie is compared with the load acting between a steel column resting through a shoe and a masonry foundation, on sloping rock. The column load is vertical, while the bearing of the wheel on the rail is at an inclination corresponding to the coning on the wheel. The track sketch is to scale, while the foundation sketch is exaggerated to emphasize the point made. The Wheel corresponds to the Column; the Rail corresponds to the Shoe; the Tie Plate corresponds to the Masonry; the Tie corresponds to the Sloping Rock.

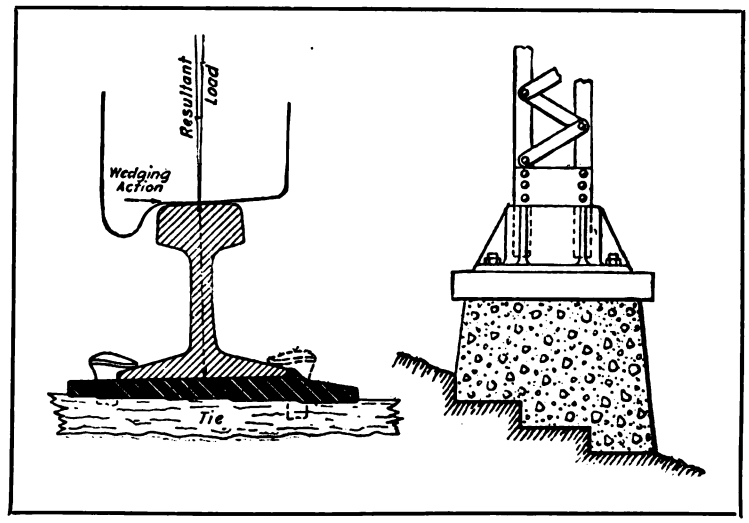

Fig. 1

has neither sharp ribs nor prongs to grip the tie, it does not rattle. It presents to the rail, when such rail is bending under load, a gently rounded surface on which the rail rolls when progressively deflected under a passing load. The rail thus never comes in contact with a sharp edge of the plate. The concave lower face of the plate acts in conjunction with the arched top surface in the elimination of noise in that it forms a definitely rounded seat and has a uniform bearing on the tie, into which it has pressed. To use a homely illustration, it has a grip on the tie somewhat in the same manner as a hat on a man's head is more secure than a book resting thereon.

The Camber

The term "Camber" as applied to the Lundie Tie Plate, refers to the definition of the word given by the best technical authorities; viz.:—the plate having an upper arched surface and a lower concaved surface; it being actually **bent** in the process of manufacture. The Lundie plate, on account of the concave undersurface and the transverse ribs, formed by the conjunction of consecutive seats on the bottom previously described, will become pinned in place, immediately on the passing over it of the first wheel load. The ends of these ribs prick at once into the surface of the tie, while the concaved lower surface flattens out, but immediately returns to its original form after the load passes. On subsequent loads passing over the plate, the before-mentioned ribs will continue to seat themselves farther and farther into the tie; and, after a sufficient number of wheel loads have passed over the plate, the concave lower surface of the plate will be found to be resting on a convex surface of the tie corresponding exactly to the concavity on the under surface of the plate. The plate has a crosswise gripping action on the tie due to the concavity as well as a lengthwise reaction against lateral thrust, due to the stepped form previously described. Moisture is excluded or eliminated from between the tie plate and the tie owing to the concavity of the plate and the convexity of the surface of the tie, and the portion of the tie under the plate will be found to be in a better state of preservation than the rest of the upper surface of the tie; indeed, the surface of the tie under the plate will become glazed and hardened. While the Lundie Tie Plate

Service Reports

That the Lundie Tie Plate has fulfilled all the claims made for it, is substantiated by the testimony of railroad men using the plate. A recent report of its service on a sharp curve, over which passes traffic as heavy as any in the Country, indicates that the plates have held firmly to gauge and that the rail on this curve, which previously had a life of about six months, has already had its life doubled, and is not yet in a sufficiently worn condition to be removed from track. Fig. 2,

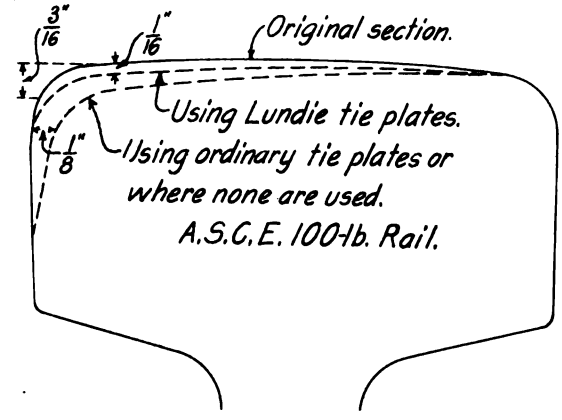

Fig. 2

taken from the records of a well-known railroad company, shows clearly the rail wear over flat plates, and the wear of the same rail, under the same traffic, over Lundie plates.

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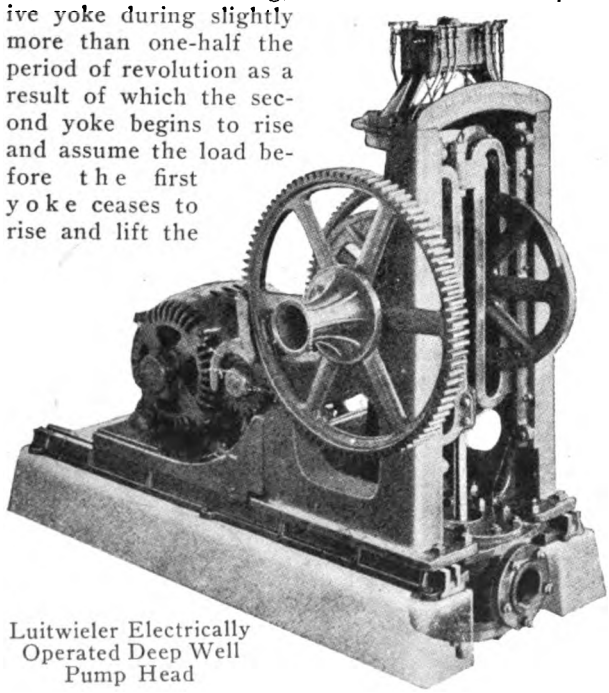
General

The Luitwieler Pumping Engine Company, with offices in Rochester, N. Y., and Los Angeles, Cal., is a manufacturer of deep well and triplex force pumps for railway service, city and village water works, private supply, boiler feeding, hydraulic elevators, manufacturing plants, etc. These pumps are the product of a company which has been directly and continuously associated with the development of pumping from drilled and bored wells since 1877, and embody a number of exclusive and unique features.

They are used extensively by railroads, one road having as many as 71 in service, and they have been in continuous duty for 20 years with only nominal expense for repairs. In a typical instance an electrically operated Luitwieler deep well pump after 10 month's operation at a heavy duty railway water station was estimated by the road to have effected savings amounting to $125 a month. In another instance four Luitwieler pumps were estimated by a railroad to have effected savings in power and maintenance during the first year of over $5,000 in excess of the cost of the installation.

The Luitwieler System

Luitwieler pumps are distinctive in that dead centers and cranks are eliminated, the rotating motion of the drive shaft being transformed into straight line motion by cams. For deep well pumping two cams are key seated opposite each other on the same drive shaft and transmit the power to sliding yokes through rollers, each yoke having an upper and lower roller. Pressure of the cam against the upper roller raises the yoke and pressure against the lower roller insures a positive downward stroke. The cams are designed, (1), so that in revolving, each cam raises its respective yoke during slightly more than one-half the period of revolution as a result of which the second yoke begins to rise and assume the load before the first yoke ceases to rise and lift the load, and (2), so that the rise of each yoke is uniform throughout the entire period.



Luitwieler Electrically Operated Deep Well Pump Head

This motion is thence transmitted to the two pistons in the working barrel of the well through pump rods, the pistons being located directly above and below each other and the pump rods for the upper and lower pistons being hollow and solid, respectively, the hollow rod enclosing the solid and operating concentrically with it. This construction provides for a continuous non-pulsating draft of water from the well, the continuity of the flow being such that no check valve is required at the intake. This together with the high degree of equilibrium obtained in the entire mechanism eliminates jar, vibration, and back lash on gearing, commonly encountered causes of low operating efficiency and rapid depreciation of equipment. The Luitwieler Company demonstrates the degree with which uniformity of operation is accomplished in their pumps by operating one of the smaller electrical drive pumps at full speed for eight minutes during which it remains supported on four pairs of common glass tumblers set bottom to bottom unbraced or fastened.

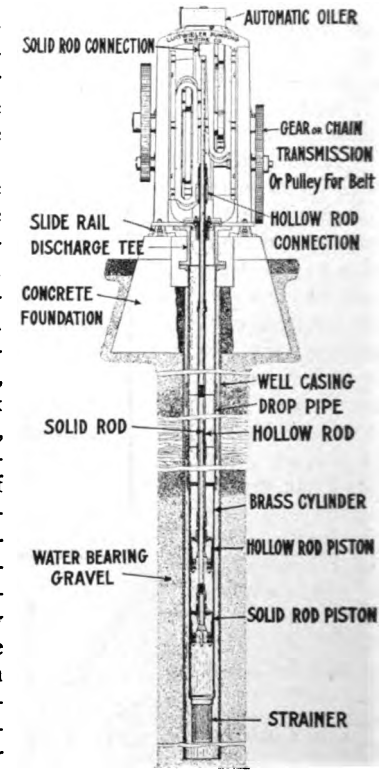


Diagram of Luitwieler Deep Well Pump

By reason of the continuity of the flow the pumps often afford the means of getting an increased supply from a well without necessitating the enlargement of the boring, of using a smaller pump, or of effecting large reductions in operating expenses resulting from the higher efficiency. The Luitwieler pumps discharge the water at a loss of only 15 to 25 per cent of the energy expended. Balanced as they are, these pumps are also adapted for automatic service, being capable of control, where electrically operated, by a float switch, as in elevated tanks or reservoirs, or on pipe lines, by pressure controls.

The company specializes in electric drive, but adapts the pumps also to steam, fuel oil, or belt drive, power units being carried on the pump jack base, directly connected by gears in deep well pumps and in triplex pumps by a chain running in an oil bath. The pumps have very few parts, all of which are easily accessible for repair, and are equipped with automatic force feed oilers. In pulling the deep well pumps it is only necessary to disconnect the pump rods and slide the head back on the sliding base. In the larger pumps a winch head on the drive shaft provides a convenient and quick means of hoisting the rods or casing.

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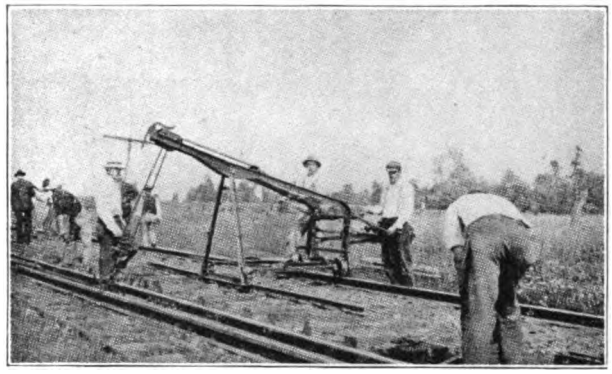
RAIL LAYER, DERRICK TRUCK CAR AND BALLAST SCREEN

General

The Maintenance Equipment Company, Chicago, formerly the Madden Company, has, from its inception, devoted its efforts to the development of maintenance devices designed to increase the efficiency of the working forces by enabling a comparatively small gang to do the work otherwise requiring a much larger one, thus effecting a saving in both time and money. With this end in view it has brought out the Three Man Rail Layer, the Derrick Truck Car, the Harris-Muff Power Ballast Screen, the Wagner Switchpoint Straightener, the Blair Tie Spacer, the Clough Unloading Hook, and the Richter Blue Flag Derail. It is also the railway representative for the Red Top Steel Fence Post.

Three Men Rail Layer

The Three Men Rail Layer has proved its worth on over one hundred different roads where it is considered practically indispensable for relaying rails. It saves the difference between the 15 to 20 men required with the

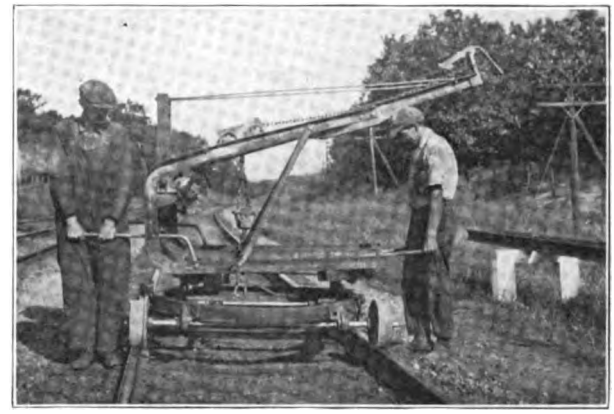


The Three Man Rail Layer in Operation

ordinary tong gang and the number required to operate the machine, ranging from 3 to 5 according to local conditions. The men thus released are available for use ahead of the machine in taking out rail, adzing and pulling spikes, and in following up, bolting, spiking, etc. The machine is adaptable to a gang of any size and has the necessary capacity for handling rails of any size.

Derrick Truck Car

The Derrick Truck Car, as its name implies, is a simple machine used for handling material around yards and terminals which would ordinarily require a full gang of men. It is equally well adapted for use in the bridge and building department. It consists of two parts, the derrick frame with circular segments on the bottom, carrying small rollers that revolve through a complete circle when necessary upon the circular angle member forming the platform of the truck itself. The truck is equipped with Shafer steel roller bearings, so that when loaded with as much as three tons it can be moved along the track with moderate effort. The hand hoist multiplies the power so that one

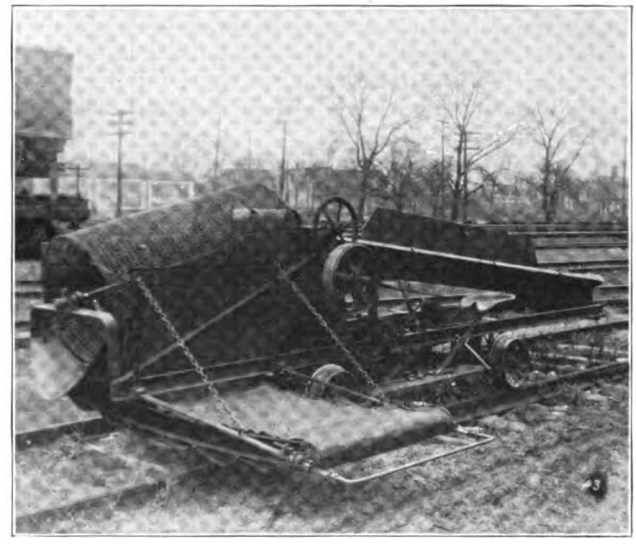


Derrick Truck Car Being Separated

man can elevate a one-ton load with the machine.

Harris-Muff Power Ballast Screen

The Harris-Muff Power Ballast Screen has been designed to fill a long felt want for a machine to supplant the cumbrous and expensive method of screening ballast by forking. The ballast to be cleaned is thrown by hand into the trough through which the conveying belt travels, carrying the ballast to the revolving screen where it is cleaned, the dirt being carried upon a canvas apron underneath from which it is removed to the side of the track for use in widening banks or for loading by train, the clean ballast being deposited in the center of the track. The machine is operated by a 15-HP, 4-cylinder gasoline engine which also propels the car either backward or forward, while cross wheels attached to the lower part of the frame enable the operators to remove the



Harris-Muff Power Ballast Screen

machine from the track in as short a time as one minute. A gang of 15 men has screened as much as 800 ft. of track in one day with this machine.

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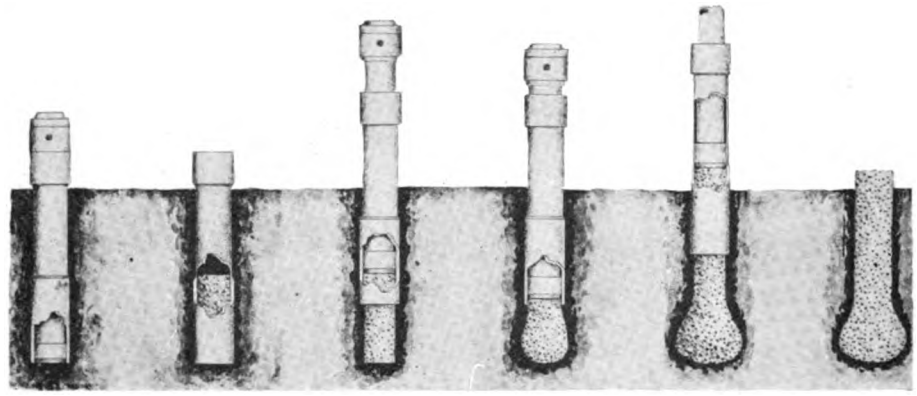
General

The MacArthur Concrete Pile & Foundation Company, 12 John St., New York, is equipped to construct pile foundations under Pedestal Pile patents in any place in North America. The pedestal pile has been established as an economical and efficient engineering structure by its use on some of the largest railroad systems throughout all sections of this country and Canada. Millions of lineal feet of pedestal piles have been driven in the United States, Canada and Japan, supporting buildings and bridges for these governments, as well as for railroads and private enterprises generally.

In the intensive construction incident to the world war the pedestal concrete pile occupied a prominent place by reason of its large factor of safety with lower requirements in materials and labor. It has been used on the railroads in the building of extensive new shops for roads on the Atlantic Coastal plain; in bridge and track elevation work on a central system; and for large viaducts, retaining walls and grade separation on the Pacific Coast, as well as for passenger and freight stations at points widely separated.



Stages in Construction of the Pedestal Pile

In designing and carrying through to completion foundations of pedestal piles the builder is thus assured of the greatest possible support for the structure, compatible with the soil encountered, and at a minimum of expense.

The company will send its engineers to any part of the country at its own expense to report on the question of a suitable foundation for any proposed structure, and will undertake and carry to completion pedestal pile foundation work in soils of any nature. The MacArthur Concrete Pile & Foundation Company has branches at Chicago, Ill., Philadelphia, Pa., Boston, Mass., Pittsburgh, Pa., Cleveland, Ohio, San Francisco, Cal., Kansas City, Mo., Montreal and Quebec, P. Q.

The Pedestal Pile

The pedestal concrete pile is a made-in-place concrete pile which has a cylindrical shaft or stem 16 in. in diameter with an enlarged base or foot as large as it is possible to make it under the compression of the steam hammer. As an engineering structure it differs from the ordinary wood or concrete pile in that a large carrying capacity, in addition to that due to frictional adhesion, is derived from the direct bearing power of the broad base resting on a firm and compacted sub-soil.

The advantage of a pile with a broad base has long been recognized by engineers. The invention of the pedestal pile devolped a means of mushrooming or bulging out such a base in a simple, practical manner so that the pile becomes capable of supporting a much larger load with only a moderate increase in cost. This type of pile has advantages over the older methods by which the hole for the pedestal was mechanically enlarged before the concrete was poured, in that the compacting action upon the surrounding soil was then lacking.

The MacArthur Pedestal Concrete Piles are formed in place by means of an apparatus consisting of a casing 16 in. in diameter into which a core or mandrel is fitted. Both are driven to penetration with a steam hammer, established pile driving methods being used. The core is withdrawn and a charge of concrete dropped to the bottom of the casing. The core is then placed on the concrete charge and the casing pulled up for a fixed distance. The steam hammer, striking on the core, or mandrel, forces this concrete out against the soil, pushing back and compacting the surrounding earth. This operation is repeated until a sufficient volume of concrete has been rammed out to insure a bulb or Pedestal of the necessary size.

The mandrel is again removed, the casing filled to the top with concrete, and the mandrel with steam hammer placed on the concrete, this total dead weight of 10,000 lb. tamping thoroughly the entire pile, while the casing is steadily and evenly pulled. This leaves a monolithic column of concrete 16 in. in diameter bonded into the small irregularities of the soil, with an ample footing or Pedestal formed on the firm sub soil and with its vertical surface pressing on the solid ground.

When much ground water or fluid soil is found at the lower end of the pile, a metal shoe may be fitted to the lower end of the core and casing as they are driven into the ground. This shoe seals the lower end of the casing while the core is being removed and the first charge is being placed. Subsequently the successive charges of concrete act as a seal while the pedestal is being formed. The shoe remains in the ground a part of the pedestal.

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It has been found that where the bulb has been formed in soil of uniform density the pedestal assumes a roughly spherical form. Where the soil at the lower side of the pedestal is firmer than the soil surrounding the upper part of the pedestal the bulb tends to flatten out on the bottom like an orange or a pear. Where the pile is driven down through very soft soil and brings up on a hard stratum the pedestal tends to take the ideal form of a truncated cone. Thus the form taken by the pedestal pile is the one that furnishes equal bearing power regardless of the kind of soil.

Kind of Material	Safe Bearing Power Tons Per Square Foot		
	Minimum	Maximum	Average
Clay in thick beds, always dry...	6	8	7
Clay in thick beds, moderately dry	4	6	5
Clay, soft	1	2	1.5
Gravel and coarse sand, well cemented	8	10	9
Sand, dry, compact and well cemented	4	6	5
Sand, clean, dry.....	2	4	3

Carrying Capacity of Pedestal Piles

When a structure is to be built on soft or unreliable ground spread footings cannot be depended upon to carry the weight without undue and unequal settlement. Piles provide increased carrying capacity by transmitting the load to the firmer and more reliable subsoil underlying the surface soil. A pile develops this carrying capacity in two ways: By the frictional resistance of its surface with the soil penetrated, and by the direct bearing of its base upon the subsoil.

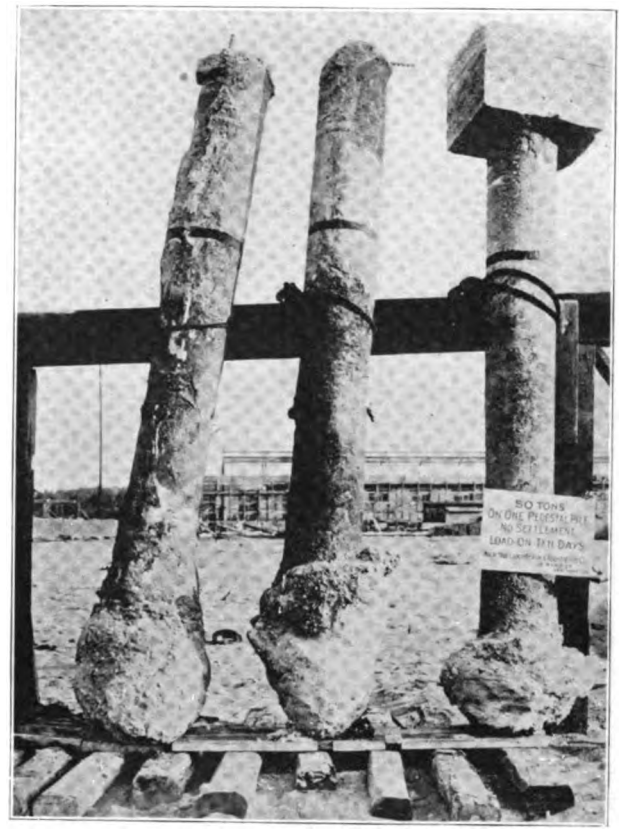
The formula stated by Patton in his book, "A Practical Treatise on Foundations" is

$$L=bA.+fS.$$

in which L is the safe supporting power of the pile; b is the safe bearing power per sq. ft. of the soil at the base of the pile; A is the area in sq. ft. of the base of the pile; f is the safe frictional resistance per sq. ft. of soil penetrated by the pile; and S is the number of sq. ft. of surface in contact with the soil.

A and S will of course always be obtained by a simple calculation from the known size and shape of the pile.

The value of b can usually be determined quite accurately, that of f somewhat less so. The latter ranges in general from 100 lb. to the sq. ft. in the softest soils to 600 lb. to the sq. ft. in compact sand and gravel. Under average conditions a direct bearing power of 5 tons to the sq. ft. of area resting on the subsoil and frictional resistance of 300 lb. to the sq. ft. of surface is conservative. A table of safe bearing power of soils, by Ira O. Baker, is given wherein is shown the correctness of the first assumption.



Examples of the Pedestal Pile

Numerous tests have confirmed the conclusions reached by the use of the theoretical formula, as the following: A pedestal pile bearing on hard clay supported 70 tons without settlement; one resting on firm sand carried 63 tons with 3-16 in. settlement; four pedestal piles driven into new sand in Quebec Harbor carried 200 tons with 3-16 in. settlement; one pile at New Bedford, Mass., was tested to 70 tons with ⅜ in. settlement.

It has thus been shown that for soils in no way favorable to the pedestal pile but representing average conditions, the latter provides practically twice the carrying capacity of a large straight pile and more than three times that of the commonly shaped pile.

The following table of carrying capacity is based on Patton's formula using b= 5 tons and f= 300 lbs.

Size of Pile	Surface Area, Square Feet	Frictional Carrying Capacity at 300 lbs. Per Sq. Ft.	Bearing Area at Foot or Point, Sq. Ft.	Direct Bearing Capacity at 5 Ton Per Sq. Ft.	Total Carrying Capacity of Pile
		Tons		Tons	
Wooden Pile 30 ft. long. Diameter 12" and 7".....	74.5	11.2	.270	1.35	12.6
Concrete Pile 30 ft. long. Diameter 18" and 6"	94.3	14.2	.205	1.03	15.2
Concrete Pile 30 ft. long. Diameter 14" and 14"	110.0	16.5	1.07	5.35	21.9
Concrete Pile 30 ft. long. Diameter 16" and 16"	125.7	18.8	1.395	6.96	25.8
Pedestal Pile 30 ft. long. Diameter 16" and 36"	125.7	18.8	7.10	35.5	54.3

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MANGANESE AND CARBON RAIL TRACK WORK

General

The Manganese Track Society is an association formed by the leading manufacturers of special trackwork such as frogs, switches and crossings. The association came into being in 1913 and devoted itself principally to the improvement of conditions then existing in the industry in connection with manganese steel track work.

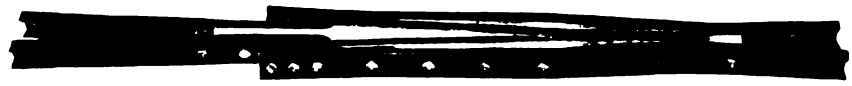

Fig. 1. Rail Bound Manganese Steel Frog
Adopted by American Ry. Engineering Ass'n.

In the four or five years following its first introduction into steam railroad track work in 1900, the economic possibilities of manganese steel had been well established and had created a demand causing most of the frog and switch manufacturers to include manganese steel track structures among their products. Lack of knowledge of the peculiarities of the metal, and of the manufacturing limitations and other factors to be gained only by experience, led to faulty designs by both manufacturers and railroads, and to the use of the structures under conditions which doomed them to practical or economic failure.

Standardization of Manganese Steel Work

The Society, in conjunction with the Manganese Steel Founders, proceeded to establish fixed standards of quality and correct designs. These are laid down in booklets with drawings and diagrams published by the Society from time to time and distributed among the engineers of the railroads. Eight booklets have so far been issued covering Sections of Manganese Frog and Crossing Castings; Designs for Crossings, Switch Points, Railbound and Solid Manganese Steel Frogs; Specifications for Manganese Steel in Track Castings; and Specifications for the Manufacture and Finish of Manganese Steel Track Work. Copies may be had from the secretary, B. M. Fosgate, 122 S. Michigan Ave., Chicago.

The Use of Manganese Steel Trackwork

The Society recommends the use of manganese steel trackwork where it will give true economy. Manganese steel track structures necessarily cost several times as much as the structures built of rolled rail only, and while the longer life of manganese steel usually overbalances the greater first cost, the item of invested capital must be taken into consideration. The life of manganese steel trackwork varies with the particular kind of structure, whether frog or crossing, and with the construction and angle, and the conditions under which it is used. Some of the determining factors for its economic use as against carbon rail work are: (1) Frequency of traffic; (2) difficulties of maintenance and the cost in particular locations; and (3) permanency of location. A longer life may not always compensate for higher first cost in the application of manganese steel to some parts of trackwork, nor where constructive difficulties or special features add to the cost of manufacture. On the other hand, in complex work, the simpler and more solid construction made possible by manganese steel castings sometimes gives sufficient advantages without regard to the wearing qualities of the manganese steel itself. (See Fig. 3.) Good foundation and adequate drainage will add to the life of any track work, but are particularly important with the more expensive manganese steel work.

Government Work

When this country entered the World War the members of the Society, anticipating the wants of the United States Government in its military railways, prepared plans and established standards in conjunction with the Government Engineers for frogs, switches, etc., which could be built by all manufacturers in the quickest possible time, whereby several months of valuable time were saved. The work consisted of carbon rail structures, without manganese steel, as best suited for the purpose; except that in certain crossings, manganese steel parts were introduced, not on account of the wearing qualities, but as they afforded the solution of a problem in the construction, permitting of changes in the field for different gages.

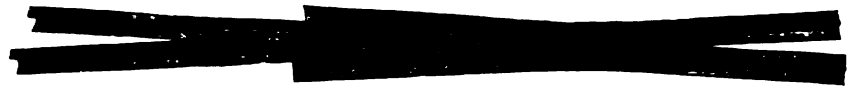

Fig. 2. Standard Bolted Rigid Frog
Adopted by American Ry. Engineering Ass'n.

Standardization of Carbon Rail Work

The work of the Manganese Track Society attracted the attention of the American Railway Engineering Association, and this has led to a close co-operation of the Standardization Committee of the Society with the Track Committee of the American Railway Engineering Association in the establishment of new standards for split switches, frogs, etc., for rolled carbon rail work, as well as for manganese steel work. The results that are being obtained from this co-operation are expected to prove of considerable advantage to the railroads, as well as to the manufacturers. The scope of the Society has thus been enlarged, and its title may have become a misnomer because it concerns itself not only with manganese steel trackwork, but with all classes of standard carbon rail work.

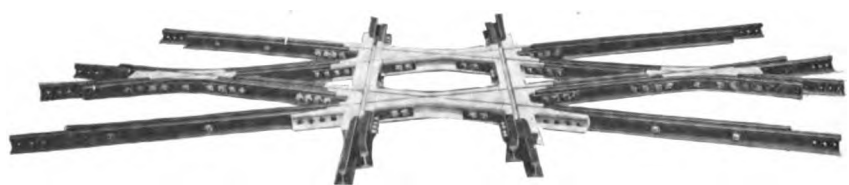

Fig. 3. Complex Manganese Crossing

MANGANESE TRACK SOCIETY, CHICAGO

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General

Massey Concrete Products Corporation specializes in factory-made reinforced concrete products. These include concrete culvert and sewer pipe, reinforced concrete bridge slabs, precast piling and highway crossing slabs. It also makes portable concrete houses, battery wells and boxes, and hollow reinforced concrete poles for bridge warning support, transmission line and street lighting use. General offices are at Chicago; district offices at New York City; Dallas, Tex.; Pittsburgh, Pa.; Atlanta, Ga.; St. Louis, Mo.; and Salt Lake City, Utah. Massey plants are located at advantageous railroad shipping centers as follows: Newark, N. J.; Pittsburgh, Pa.; Columbia, S. C.; Chatham, Ont.; Montreal, Que.; Minneapolis, Minn.; Chicago, Ill.; Dallas, Tex.; Kansas City, Kans.; Los Angeles, Calif.; Spokane, Wash.; Memphis, Tenn.; Milwaukee, Wis.; and Salt Lake City, Utah.

Precast concrete units made by the Massey Concrete Products Corporation possess the advantage of being easily and rapidly installed, permanent, of high quality, and are especially adapted for railway use. To the maintenance man they offer an economical solution of his labor problems in connection with his concrete work. It is suggested that a conference with Massey engineers may give him valuable assistance.

Massey Railway Culvert Pipe

Correctness of Massey Reinforced Concrete Railway Pipe design is best shown by the large number of railroads which have adopted it as standard culvert construction. The oval shape is the most widely known type. It contains a single line of reinforcement, placed in the region of tension, accurate spacing being assured by a circular reinforcing cage. "Top" is imprinted at the ends of the vertical axis so that no doubt can exist as to whether pipe is properly laid, when this word appears on top. Pipe designed for railway culverts is designated as Class "B," while Class "A" is used for heavier highway culverts and Class "AA" is used for sewers and ordinary culverts. Particular attention is called to the excess water area in the oval section over the corresponding round section. Massey Corporation is equipped to furnish reinforced concrete pipe, meeting general specifications for any type of work where precast concrete pipe can be used.

Massey Railway Culvert Pipe

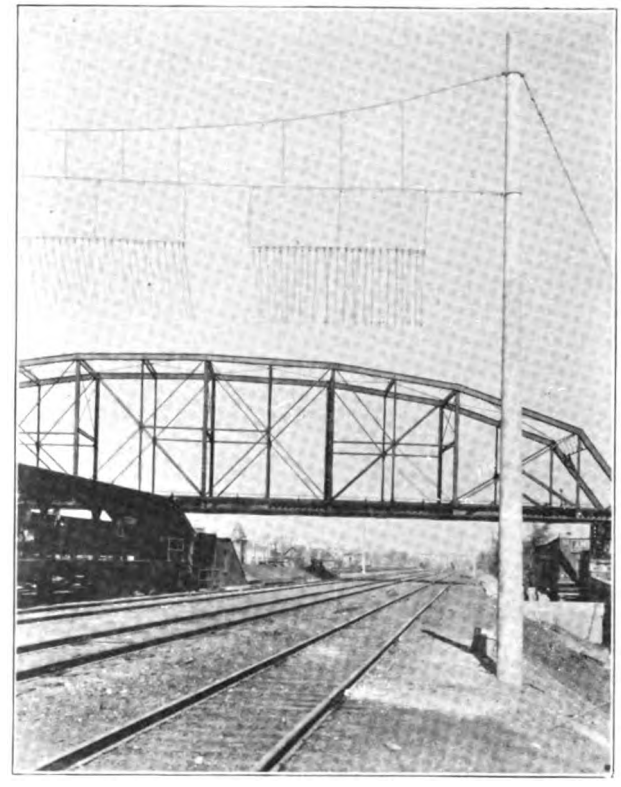
Massey Structures for Railway Signaling

Massey battery wells and boxes are used by most railroads in the United States and Canada. The several designs make it possible to secure battery housings for any given installation. In addition to the wells and boxes, the railway signal appliances include the signal cellar, which is a combination well and mast foundation; cable posts; signal and cable post foundations and manholes.

Hollow Concrete Poles

Massey Corporation also manufactures, by the centrifugal process, poles for bridge warning, telegraph and transmission line use, as well as lighting standards. These poles are made by revolving a mixture of the concrete ingredients and reinforcing steel together with the metal molds, at a high speed in a special machine. The centrifugal force makes a hard, compact, waterproof concrete of great density, whose ultimate strength is far greater than that obtainable by ordinary methods.

It is impossible to cover all the structural details in a written description, but Massey Representatives will be glad to give all the details upon request.



Massey Concrete Poles Supporting Bridge Warnings

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General

The McMyler Interstate Company, with its main office at Cleveland, Ohio, and its works at Bedford (a suburb of Cleveland), specializes in the manufacture of material handling and construction equipment. Its products include car dumpers, traveling gantry cranes, locomotive cranes, ore and coal handling machinery, orange peel, clamshell and scraper buckets, locomotive pile drivers and similar railroad equipment. The company maintains branch offices in New York City; Chicago, Ill.; Seattle, Wash.; Denver, Colo.; San Francisco, Cal.; Birmingham, Ala.; Boston, Mass., and New Orleans, La.

The two machines manufactured by this company which are of most direct application to maintenance of way work are pile drivers and locomotive cranes. Such machines have all along played a prominent part in new construction work. More recently, through improvements devised for the former, such as the self-propelling mechanism, and through the feature of adaptability effected in the latter by the addition of accessories, such as the clamshell bucket, fall blocks with hooks, electric magnets, etc., the use of both in maintenance work is being extended constantly.

The No. 12 Locomotive Pile Driver

Time is often a critical factor in pile driving work; also in such operations the driving of the piles is generally within reach from existing tracks and the need is always insistent that these tracks shall not be occupied longer than is required. This makes it highly desirable that the driver may be moved over the road by its own power, and it must similarly be possible to bring the leads within the standard clearances. The McMyler Interstate Company makes four standard railroad pile drivers which meet the entire range of requirements in this service. Among these, and a further complete line of pile drivers, the company calls special attention to its No. 12 type, which has a number of features adapting it particularly to maintenance work.

The No. 12 Driver differs only in detail from the other types of railroad pile drivers made by this company. It is of the turntable type, is self-propelling and is equipped with either drop or steam hammer. The principal features embodied in its design and construction include:

(1)—Equal wheel load distribution when collapsed for transportation.

(2)—Comparatively long reach in all directions without the necessity of turning the car about.

(3)—Direct lead of all operating cables, thereby avoiding reverse bends.

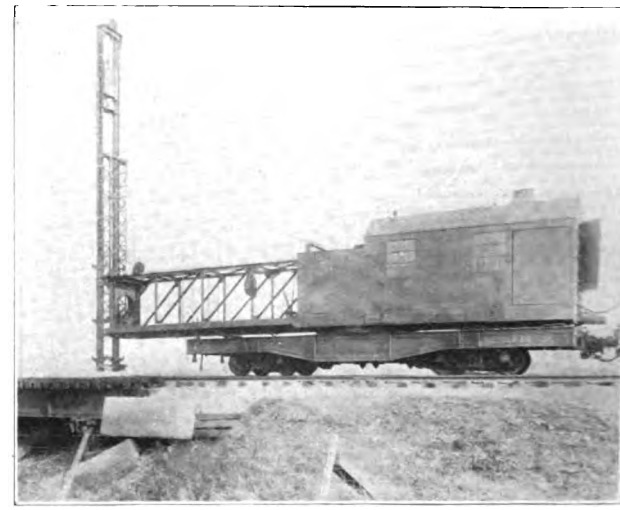
(4)—Train and locomotive air brake equipment and powerful propelling mechanism which dispenses with the need for a locomotive.

(5)—Rigid construction.

(6)—Simplicity of operation.

(7)—Accessibility to all mechanism.

The reach from the center of the forward axle at either end of the car to the center of the leads is 20 ft. 3 in., and from the center of the track to the center of the leads at right angles to the track is 33 ft. 9 in. The car has a total length, out to out of end sills, of 37 ft. 6 in. and a clear width of 9 ft. 10 in. The height from top of rail to top of housing, the stack and hood being removable, is 15 ft. 3 in. The width of the top of the housing is 5 ft. 0½ in. The car is thus within the limit of ordinary clearances.



McMyler No. 12 Locomotive Pile Driver

The operating machinery consists of two sets of engines. The forward set operates the propelling mechanism, the slewing mechanism and the leader raising and lowering winch while the rear set operates the hammer and pile lines.

The leaders are built up of standard steel shapes and are provided with the necessary cast steel yokes, toggles and leading sheaves. They are 42 ft. long and the hammer guides on standard leaders are 7 in. wide with 25½ in. between faces. The leaders are hung in a swivel at the top of the truss and further supported near the bottom of the truss by the swivel attachment. For driving batter piles, the leaders may be inclined at any angle up to one horizontal to six vertical. This swivel attachment is operated by means of a hand wheel connecting with suitable gearing to pinion in mesh with the circular rack. The operating levers are banked on the turntable forward of the center at which point the operator has a clear and unobstructed view of the work in hand. The close proximity of the operator to the leaders also enables him to work to advantage.

Drop hammers or steam hammers may be operated on these machines with equal facility. Unless otherwise specified, the weight of the drop hammer furnished is 3,200 lb. Hammers equivalent to the No. 2 Union or No. 2 Vulcan, are also suitable for operation on these drivers. All drivers are arranged with a steam pipe for connecting steam hose for a steam hammer. When steam hammers are furnished with the equipment, the required length of steam hose is also supplied.

The shipping weight of the machine is 132,000 lb. exclusive of the hammer. The weight in working order, not including hammer, is about 140,000 lb.

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Locomotive Cranes

The uses of locomotive cranes in maintenance are so numerous as to forbid narration. The most common applications are for loading and unloading heavy material; erecting structures; handling scrap by means of slings, or generator and magnet attachment; grading, either in cut or fill, with an orange peel or a clamshell bucket or with a dragline excavator; unloading and transferring the lighter materials in bulk; driving piles, when equipped with the necessary attachment. raising and lining track; spotting cars; and as accessory equipment in handling materials and placing concrete in close quarters, such as the reconstruction of turntables, etc.

The locomotive cranes manufactured by the McMyler Interstate Company are the result of 35 years of engineering experience. They are built in many different varieties, enabling the one to be selected which is best adapted to a required service. The versatility of these cranes is one of their notable points, by which a crane may be diverted to a different kind of work without loss of efficiency. This also extends to their detailed performances.

The McMyler Interstate cranes are rapid in their action, 90 trips per min. having been recorded and 75 per min. not being an unusual occurrence. They are provided with all necessary safety appliances which make them especially attractive equipment in railroad work. They are designed to operate with either steam or electric power.

McMyler Interstate cranes are of two general classes, the 4-wheel, of 10 and 15 tons capacity, and the 8-wheel, of 15, 20, 25, 35 and 40 tons capacity. The smaller cranes can be used to advantage where space is limited and where no great amount of traveling is done. The longest boom supplied with this type, and with the lightest of the 8-wheel types, extends 50 ft. beyond the crane center. The two larger cranes are of use where a reach up to 70 ft. is necessary and where heavy work is to be done. The 70-ft. booms have a central section of 20 ft. which may be removed where a shorter reach is desired.

The 8-wheel cranes have the capacity and speed to handle successfully the larger jobs where a crane of the usual size would not suffice. They are of Type J, 40 and 35 tons, Type H, 25 tons, and Type B, 20 and 15 tons. They are mounted on two 4-wheel M. C. B. trucks, fitted to operate on 4-ft. 8½-in. gage track, and are shipped from factory to destination on their own wheels. They are supplied for operation by steam or electricity as may be specified. The boom is of the length desired up to the maximum. The standard equipment of the Type J, which applies to other types except as noted, includes two power drums for hoisting; the necessary plow steel operating cables; complete air brake equipment, including air pump, engineer's valve, etc.; jack arm swing-type outriggers, and tool box with tools. In the Type H and B cranes freight car air brakes are supplied, but locomotive air or steam brakes can be furnished extra if preferred. Outriggers are extra for the Type H crane and are not supplied with the Type B crane. The double power drum arrangement is one of the special features of the McMyler cranes, permitting the handling of either heavy or light loads at speeds consistent with efficiency and safety.

Standard accessories with which these cranes can be supplied, when ordered as extras, are as follows:

(1) Fall blocks with swivel hooks.

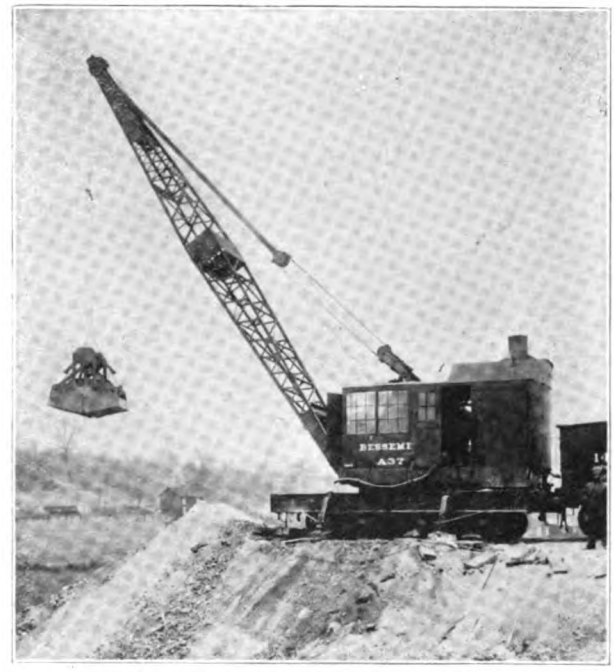
(2) Two-line buckets of the clamshell, orange peel, bottom dump or scraper type.

(3) Electric magnets for handling steel and iron.

(4) Generator sets of suitable capacity for energizing or lighting service.

(5) Electric plug-in attachments in the car-body for taking power from adjacent feed lines by means of a flexible cable.

(6) Pile driver leads up to 50 ft. in length, fitted with drop hammers or steam hammers. The leads are of the (a) suspension type attached to the tip of the boom with base strut; or (b) standard No. 10 railroad type, consisting of horizontal truss with swivel leads, which are furnished only with the Type J crane. The No. 10 attachment is all-steel, and the leads may be lowered to bring the machine within clearance. Goose neck booms are not infrequently desired where conditions require high clearance under the boom, as in working over an intervening car.



A McMyler Locomotive Crane

The cranes made by the McMyler Interstate Company have large tractive capacity and show a dependable performance in any work. A roomy cab, with the operator placed where a wide view may be obtained, is a feature of their design. The buckets supplied are rapid in action and operate smoothly under all conditions. The magnet and generator are of particular use in picking up scrap and handling materials at maintenance of way reclaiming yards, while the electric lighting plant possesses a large advantage over oil lamps in any service.

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General

The Marion Steam Shovel Company, Marion, Ohio, builds steam, gasoline, and electric shovels, ditchers, dredges, clam-shell and drag-line outfits, cranes, ballast unloaders, and similar excavating machinery. Marion equipment has been on the market for 37 years, during which time it has been associated with many notable undertakings, such as the Panama Canal, in the construction of which 29 of its steam shovels were employed. The equipment is widely used on railroads, on all kinds of general construction, in mining operations, drainage and irrigation, and is known internationally. The company has branch offices in New York, Chicago, Altanta, Ga., and San Francisco, Calif., and is represented in 11 other cities of the United States and Canada. Its factory occupies 75 acres.

Marion Railroad Type Steam Shovel

Marion Steam Shovels

The Marion Company is known by railroads particularly as a manufacturer of steam shovels. Its line includes both the revolving and railroad types, the latter with its body stationary and the boom operating on a swinging circle, being the one ordinarily used in this field. The shovels are made in several models, all of which are of simple design and rugged construction, and are capable of easy operation. General specifications covering their construction include hammered steel shafts, machine cut gears and pinions, open hearth steel castings specially heat treated to resist wear and shock, manganese steel castings, and a number of other features which study and an extended experience have shown to be of advantage in securing uninterrupted performance and low maintenance cost. All shovel parts are machined and fabricated on the duplicate system of gages, jigs, and templates, thus insuring uniformity and interchangeability. The boilers conform to standards that permit of their operation in any state or province of the United States or Canada.

Marion Ditcher

The Marion railway ditcher, Model 21, is an adaptation of the company's revolving type of shovel to the railway needs involved in constructing and maintaining ditches or similar work. It is identical in material and workmanship with the larger and heavier types of shovels, and embodies several distinctive features, including a central valve single lever-operated engine reverse, and a sheave block directly connected to the dipper. The ditchers operate in a complete circle, are mounted on self-propelled trucks for traveling on a flat car, and are equipped with boom hoists. The boom and dipper handle are somewhat longer than those of the shovels in order to obtain greater working range. When not required for ditching purposes, these machines can be employed advantageously in a variety of small shovel work, and by interchanging the regular boom and dipper handle for a crane boom, they can be converted readily into a material handling crane, clam-shell, or drag-line outfit. Also standard shovel trucks and lower frame can be substituted for the ditcher mounting when so desired.

TABLE OF DATA FOR MARION DITCHER AND RAILWAY TYPE STEAM SHOVELS.

Model—	21RRD	41	51	61	70	76	92	100
Weight, working condition, tons	22	47	68½	82½	94	107	121	135½
Capacity of dipper, cu. yds.	¾	¾-1½	1½-2¼	2-3	2-3½	2½-4	3-5	3-6
Capacity per hour, cu. yds.	30-60	60-180	80-270	120-350	125-375	150-400	200-500	250-550
Boom, length	20'0"	20'0"	23'0"	25'0"	27'0"	28'0"	30'0"	32'0"
Swings back of right angle		40°	10°	10°	5°	5°	5°	5°
Dipper handle, length	15'0"	12'6"	15'0"	16'0"	17'0"	18'6"	19'6"	19'6"
Boiler, 150 lb. max. press., size	45⅜x8'0"	50x10'0"	50x12'0"	54x12'6"	54x14'0"	60x14'0"	60x15'0"	60x17'0"
Engines, independent, hoisting	6x6	8x8	9x11	10x12	11x12	12x14	12x16	13x16
crowding, swinging	4½x5	5½x6	6x7	7x8	7½x8	8x8	8x8	9x9
Capacity of water tanks, gal.	308	780	1300	1494	1494	1494	1494	1890
Height A—frame (gantry for ditcher)**	11'6"	13'9"	17'0"	18'2"	19'0"	19'8"	19'11"	21'0"
*Radius of cut at grade	20'4"	13'6"	15'6"	17'0"	18'0"	19'0"	20'0"	20'0"
Radius of cut at 8' elev. above rail	29'11"	23'0"	25'6"	29'0"	30'0"	31'0"	33'0"	33'0"
Largest dumping radius	28'0"	20'4"	24'3"	25'10"	27'4"	29'0"	31'2"	31'1"
**Dumping height above rail	7'3"	12'0"	14'6"	16'0"	16'6"	17'0"	17'0"	17'0"
Radius of boom	21'10"	15'10"	18'0"	19'9"	21'2"	21'10"	23'4"	24'9"
†Height of boom above rail	13'7"	19'6"	23'0"	24'7"	26'6"	27'7"	29'6"	31'4"
§Depth will cut below grade	9'0"	4'4"	4'11"	5'0"	5'2"	6'2"	6'9"	6'1"

*With ditcher boom at 30 deg. **Above flat car for ditcher. †Above flat car for ditcher. §Below flat car for ditcher.

Marion Railroad Ditcher, Model 21

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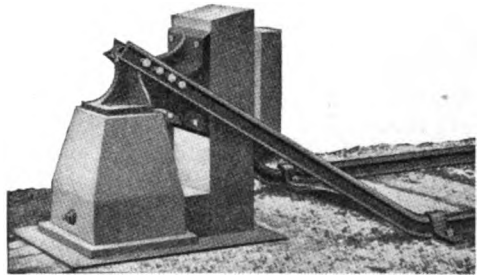
BUMPING POSTS

General

Bumping posts constitute an important item of equipment on every railroad. That they have come to be so extensively used is natural, once types were developed which could meet the requirements of engineering design and cost and at the same time could be relied upon to accomplish their object with certainty. Their value lies in their ability not only to protect the railroads against damage to equipment or property in preventing cars from running over track ends, dropping off trestles, pitching down embankments, colliding with buildings, etc., but also in providing a constant safeguard for thoroughfares, concourses, work shops, etc.



The Ellis Freight Car Bumping Post

The extent to which a railroad is justified in installing such devices obviously depends upon the conditions. In places such as depots where pedestrians would be in danger, because of the ever-present possibility of accident, were it not for the presence of a reliable bumping post, the device plainly renders a constant service. On the other hand, by actually preventing a derailment which, unprevented, would have caused extensive damage, the bumping post, in a single stroke, usually repays the cost of its installation many times over; or, for that matter, the cost of a great many installations. Very often the devices amply justify their use merely in preventing frequent derailing delays.

The Ellis Bumping Post

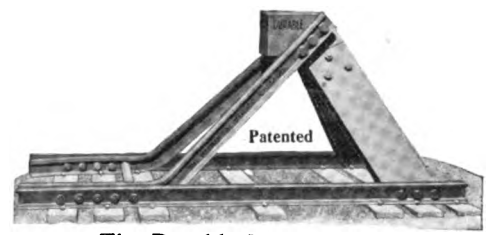
The Mechanical Manufacturing Company, Chicago, makes two styles of bumping posts, the "Ellis," and the "Durable," the "Ellis" being the better known of the two. The Ellis was the first commercial post on the market, has been in use for over 30 years, and is the standard of the majority of American railroads. It consists essentially of an upright timber post, upon the face of which, car coupler high, is bolted a buffer, and to the back of which is bolted a large casting, the heel of which is mounted upon a large timber stand, and to the sides of which are bolted the converging ends of the track rails. In the Ellis bumping post intended for freight car tracks, the buffer consists simply of a timber block faced with a metal plate. In those intended for passenger car tracks, the buffer consists, in addition to the timber block, of a tough rubber cushion 12 in. in dia., held in a cast iron seat, and a steel cap, the cap being attached to a spindle which extends through the post. The post and stand are bolted together at the bottoms and are supported on a timber base, and the bent rails at the end of the track are bolted down to an anchor timber in the ground.

The Ellis post is simple in design, great in strength, long in life, and can be installed easily and quickly. The timber is ordinarily of fir or oak, while the rails are of open hearth steel made according to standard specifications for soft steel to afford adequate toughness under the sudden shocks to which the posts are subject. It is also of neat appearance, occupies little space lengthwise in the tracks, and is adaptable to all positions. These posts received the highest award at the World's Fair, St. Louis. Among the passenger stations in which the Ellis is installed are the following:

Pennsylvania Terminal Station	New York
Terminal Station	St. Louis
Union Station	Boston
New York, New Haven & Hartford	Providence
Union Station	Duluth
Central Union Depot	Cincinnati
Wabash Terminal Station	Pittsburgh
Birmingham Terminal Station	Birmingham
Philadelphia & Reading R. R.	Philadelphia
New York Central & Hudson River	Buffalo
Gulf, Colorado & Santa Fe	Dallas and Galveston
Savannah Union Station	Savannah
Toledo Terminal Station	Toledo
Washington Terminal Station	Washington
Grand Central Station	New York
La Salle Street Station	Chicago
Canadian Pacific Station	Montreal
Grand Trunk System	Chicago & Montreal
Lehigh Valley	Buffalo
Richmond Terminal Station	Richmond
Charleston Union Station	Charleston
Union Station	Detroit
Illinois Central	Chicago and New Orleans
Pennsylvania Lines	Chicago
Northwestern Lines	Chicago
St. Paul Union Depot	St. Paul

The Durable Bumping Post

The Durable Bumping Post is a recent development by The Mechanical Manufacturing Company for installation on surface tracks where less expensive equipment is entirely suitable and where an all metal post is desired. This post consists of sections of bent rails bolted to the inner bases of the track rails and terminating in a steel buffer block which is supported by steel channels, the channels having their lower ends also bolted to the inner bases of the track rails some distance back of the center line of the buffer block. That these posts are stout is indicated by the fact that under an impact of 102,000,000 ft. lbs. delivered by a test car, the Durable Post held securely and remained uninjured.



The Durable Bumping Post

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Waterproofing, Bridge Deck and Pressure

There are three elements to the successful solution of any waterproofing problem: design, material, application. The proper solution of each is necessary if the results are to be effective and permanent; and as water, as a solvent, a corrosive agent, and a conductor of electrical currents, is one of the main causes of depreciation, effective and permanent waterproofing is of prime importance to the railway engineer.

DESIGN: In the design of the structure, the element of first importance, there are certain principles

Tunkhannock Viaduct; Waterproofed by Minwax System

which form a basis upon which each problem can be handled. They are as follows:

For foundation (sub-level) construction:

1. The waterproofing should encase the entire structure below the grades in a continuous sheath.

For solid deck bridge structures:

1. The design should provide for rapid drainage of water off the bridge and away from adjacent construction.

2. The waterproofing course is the true drainage surface and openings to the drains should be provided at this level.

3. At all breaks in the waterproofing course, as at drains, and at all edges, such as occur adjacent to girders, parapets, or curbs, special provision should be made by flashing, etc., to insure a watertight seal.

4. All avoidable strain on the waterproofing should be prevented by folds at expansion joints, and grooves and folds over column lines and joints where reverse bending moment may occur.

5. An adequate means for protecting the waterproofing course against puncture should be provided and placed immediately following the waterproofing work.

The various cuts shown of waterproofing details are taken from work on which the Minwax system has been used and are indicative of the present accepted practice. A consulting service is maintained which is at all times at the service of engineers desiring data on waterproofing problems.

MATERIALS: There are several basic requirements which railroad construction imposes on waterproofing materials. They are:

1. Elasticity: so that if cracks develop the waterproofing blanket will span them without rupture and consequent failure, and so that temperature movement, which occurs in each element of surface (the resultant of which shows at the expansion joint) will not cause fracture.

2. Low susceptibility to temperature variations: so that vibration and movement at low temperatures will not shatter the material, or high temperatures cause fluidity and consequent flow and failure.

3. Permanence: perfect chemical and physical stability and complete resistance by all elements of the system to water and to acids or alkalis that may be carried by the water in solution.

The careful consideration of each of the factors is necessary, for the excessive cost, if not entire impracticability, of repairs to railroad waterproofing, make the selection of a permanent and efficient waterproofing system of large importance.

That access to known values in the designing of engineering structures is important is a truth that applies particularly in waterproofing work, because of the permanent character of the structure, and because the chemical complexity of bituminous materials is such that our present tests, both chemical and physical, give no satisfactory measure of their permanence; and accordingly on work of this kind a record of service should invariably be obtained of the waterproofing not as unrelated materials but as a true system.

APPLICATION: The problem of applying waterproofing materials is one of relative simplicity yet one which requires great thoroughness, attention to detail, and a real effort on the part of superintendents and workmen to produce the desired results.

In order that it may furnish maximum co-operation, the Minwax Company maintains both a corps of waterproofing foremen, capable of starting or carrying through an entire installation, and a list of waterproofing contractors, experienced in railroad waterproofing work. This service is at all times at the disposal of railroad engineers.

The Minwax System

The Minwax System developed by the Minwax Company, Inc., of New York, Chicago, Philadelphia, meets all of the requirements of efficient waterproofing. It is the original cotton fabric membrane system and consists of two plies of Minwax Asphalt Saturated Cotton Fabric and three swabbings of Minwax Waterproofing Asphalt. The elements of this system were specifically designed to function in combination,

Penn. Freight Terminal, Chicago. Driveways Waterproofed by Minwax System

each supplementing and reinforcing the other and merging into a true unit system of waterproofing.

The sheathing or blanket, which is built up from these elements on the work, furnishes great elasticity, toughness, flexibility, and watertightness. Its stability and permanence have been amply

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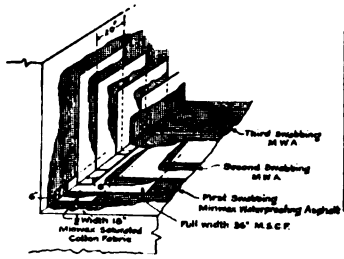
demonstrated by a record of efficient service extending over fifteen years.

On solid floor ballasted bridges, viaducts, building foundations, pump wells, retaining walls, coal pockets and other types of railroad construction, the Minwax system has rendered efficient service. Among the American railways using the Minwax system both in construction and maintenance work are:

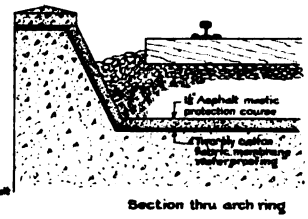
Baltimore & Ohio	Erie
Boston & Albany	Indianapolis Union
Chicago & Alton	Long Island
Chicago & Northwestern	N. Y. Central
Chi., Burlington & Quincy	New York Municipal
Chi., Milwaukee & St. Paul	Norfolk & Western
Chicago Union Station	Pennsylvania
Del., Lack. & Western	Phila. & Reading

Specifications

Materials: The waterproofing system shall consist of two plies of Minwax Saturated Cotton Fabric laid in three swabbings of Minwax Waterproofing Asphalt. Materials shall be delivered on the job in original unbroken packages, clearly labelled.

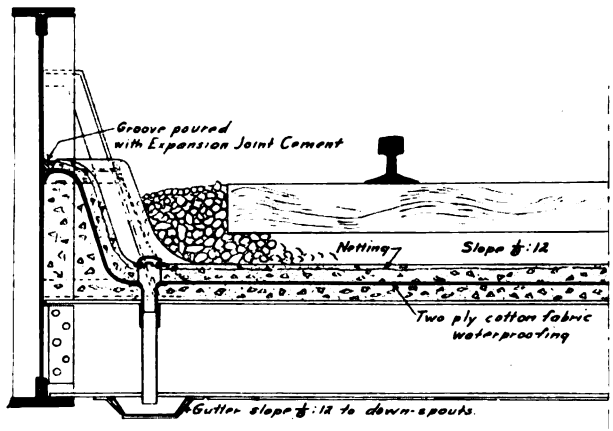


Shingling Method of Applying the Minwax Membrane System of Sub-Level Waterproofing.



Waterproofing Design Used by the D. L. & W. R. R. for Filled Concrete Arches.

Fabric: The fabric shall be thoroughly saturated with asphaltic bitumen, which shall be the same as that with which it is applied and shall meet the specifications for bitumen below. No oils, petroleum residues, nor other bitumen solvents shall be used in the impregnation of the fabric. The fabric, untreated, shall contain no oils of any kind, and shall weigh not less than 5 oz. per sq. yd. and, when saturated, not less than 14 oz. per sq. yd.; shall have a tensile strength of not less than 60 lb. per inch in either direction, on a standard paper testing machine; shall stretch at least 10 per cent in any direction without breaking, be pliable at all temperatures, and shall not flake nor crack when folded on



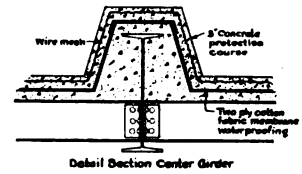
Waterproofing Design Used by the N. Y. C. R. R. for Through Girder Bridges

itself, nor be coated with talc, wood pulp or other substance which may prevent adhesion.

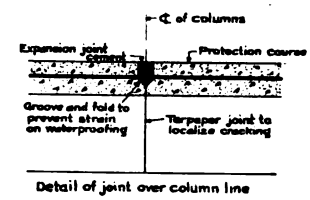
Asphalt: Plying cement shall be a naturally occurring asphaltic bitumen obtained by direct heat refining, shall be chemically inert and impervious to and unaffected by water, alkalies in cement, or acids in cinders; and shall pass satisfactorily the following tests:

Melting point	170 deg. F.
Penetration at 32 deg. F.	11 min.
Penetration at 77 deg. F.	30
Penetration at 115 deg. F.	90 max.
Penetration at 77 deg. F. after heating	26
Ductility at 77 deg. F.	12 cm.

Loss in heating at 325 deg. F for five hours. Trace



Design Providing a Continuous Waterproofing Blanket Over Center Girder in Through Bridge Construction; Used by N. Y. C. R. R.



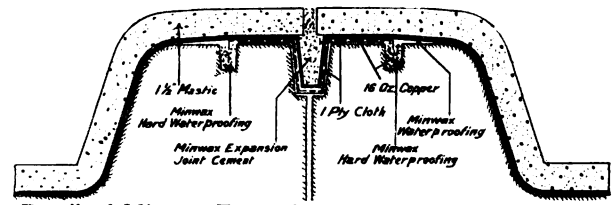
Design Providing for Expansion Without Endangering the Waterproof Blanket.

Service Record: Materials submitted for use shall be accompanied by a service record showing their use as a system for at least five years, together with names of the architects or engineers in charge of the developments.

Preparation: All surfaces will be substantially clean, smooth, free from dirt or projections which may cause puncture.

Application: Waterproofing blanket shall be built up shinglewise; each layer lapping the preceding layer 20 in., laid in and swabbed with hot asphalt, flat, without pockets, ridges or air-holes, so that there shall be two layers of fabric and three swabbings of asphalt, allowing not less than 25 yd. of fabric and 12½ gal. of asphalt per hundred square feet of surface. Asphalt shall not be heated over 350 deg. F. Final swabbing shall completely conceal the weave of the fabric. All laps or connections between waterproofing courses shall be at least 9 in.

Protection: All waterproofing shall be carefully protected immediately after application.



Detail of Minwax Expansion Joint Used by D. L. & W. R. R. on Tunkhannock and Martin's Creek Viaducts

Minwax Expansion Joint Cement

Reference is made in several of the details, to Expansion Joint Cement. This material is an asphalt refined particularly for this purpose. When heated and poured, it develops a perfect bond to surfaces in contact with it, forming an absolute seal. It is ductile under all climatic conditions and makes a perfect material for the purpose for which it is designed.

For joints that are sloping Minwax Fibrous Expansion Joint Cement should be used.

Minwax Publications

Any or all of the literature listed below, dealing with the engineering phases of protection as well as describing products, will be sent on request: Catalog, Minwax Products of Standardized Structural Protection; Bulletin No. 21, Sub-level Waterproofing; Bulletin No. 22, Waterproofing Exposed Walls; Bulletin No. 23, Concrete Floor Treatments; Bulletin No. 24, Protective Metal Coatings.

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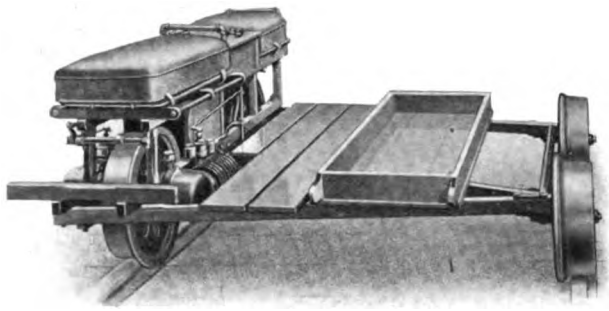
General

The entire manufacturing facilities of Mudge & Company are devoted to the production of railway motor cars, hand cars, push cars and pressed steel wheels. This specialization enables the company to concentrate its efforts on the perfection of this single line of maintenance equipment.

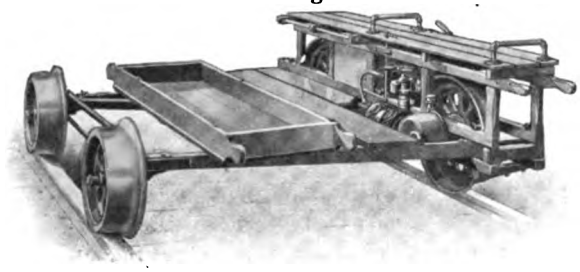
The main office of Mudge & Company is at Chicago.

Motor cars made by Mudge & Company are distinctive in having an engine interchangeable between section and inspection cars. The company makes only two types of engines for its eight models of cars, which include a section car top for application to hand cars. These are the class "E" engine, which has a 4¼ in. by 4¼ in. cylinder, and the class "G" engine, which has a 4½ in. by 5 in. cylinder, both types being two-cycle and air-cooled. Cars of the Class "E" and "G" series have engine parts which are interchangeable with all other cars of their respective classifications.



Mudge "Hill-Climber" Class E-4

The class of engine used with a Mudge car determines the first letter of its classification, the letter being used alone when the car is an inspection model, and being followed by the letter "S" when the car is a section model. A figure following the car classification denotes the number of the car with reference to its particular modifications of type. The letter "K" following the model letter and number indicates a Kerosene burning car.



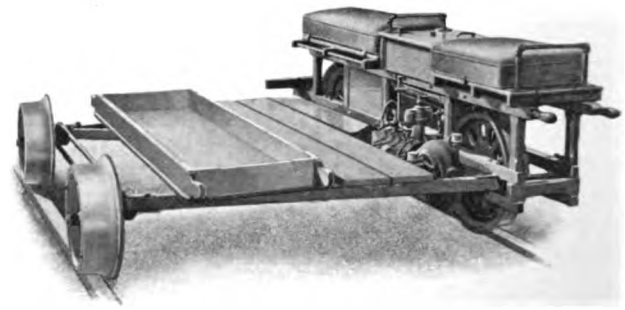
Mudge "Special" Class E-1

Mudge "Special" Inspection Car Class E-1

An efficient car for inspection service is the Mudge "Special," which is an all-round car, capable of carrying three men, yet light enough to be handled easily by one person, its total weight being but 350 lb. This car, which has a one-cylinder, 4-hp. engine, is a favorite selection for linemen, signal-men, claim adjusters, patrolmen, station agents and inspectors, for use where grade conditions are moderate. The car has removable guide arms, wheels and tray, and can be taken down quickly for loading in baggage cars.

"Power Queen" Inspection Car Class G-2

The "Power Queen" has the extra power needed to take care of requirements above the average, but where operating conditions cannot be called severe. It has a single cylinder 6-hp. engine, weighs 440 lb., and can be handled on and off the track by one man.



Mudge "Power Queen" Class G-2

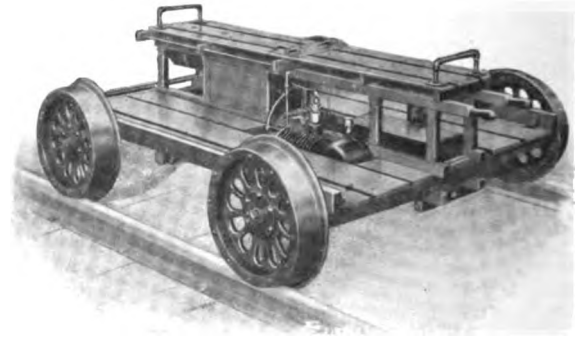
The car frame, including cross arms, foot board, tool tray, gas tank and cushions are the same as used on the class E-4 car.

"Hill Climber" Inspection Car Class E-4

Another Mudge inspection car is the "Hill Climber" which is built specially for heavy service and for the unusually severe requirements attending steep grades and high winds. It has a two-cylinder, 8-hp. engine, weighs 500 lb. and will carry four persons on grades up to 3½ per cent. Each cylinder has its individual carburetor and control levers, permitting either cylinder to be cut out at the will of the operator when full power is not required. The cross arms, guide wheels, tray, etc., are applied in the same manner as, and are interchangeable with, those used on the class E-1 and G-2.

"Safety First" Inspection Car Class E-6

The "Safety First" is an advanced type of inspection car, carefully designed to meet the demand for a safe, reliable, easily handled, center-load car. The single cylinder engine develops 4-hp., and is capable of carrying three men



Mudge "Safety-First" Class E-6

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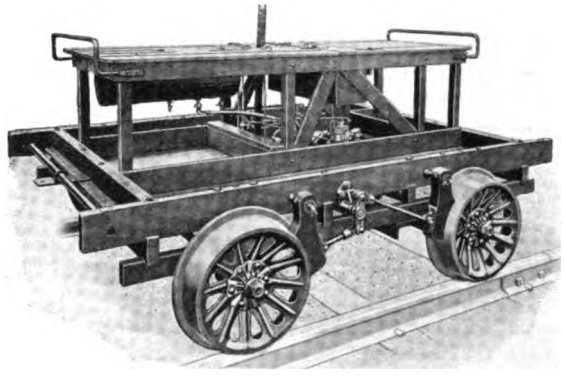
and tools where operating conditions are not unfavorable. The car operates equally well forward or backward, and is built in both the kerosene and gasoline models. Its weight is 440 lb.

"Standard Section" Motor Car Class ES-2

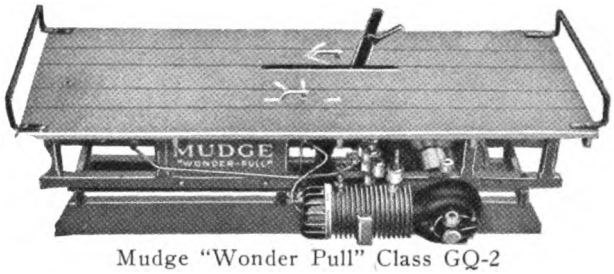
For ordinary section service the ES-2 motor car is the preferred type. It seats 10 men and will haul a loaded trailer. The two-cylinder engine develops 8-hp., and operates on either gasoline or kerosene. The power plant is mounted on an independent steel sub-frame which can easily be removed from the car. Power is transmitted through hardened steel gears to the driving axle which runs in Hyatt roller bearings. The car operates equally well forward or backward, and weighs 875 lb.



Mudge "Standard Section" Class ES-2

"Wonder Pull" Equipment Class GQ-2

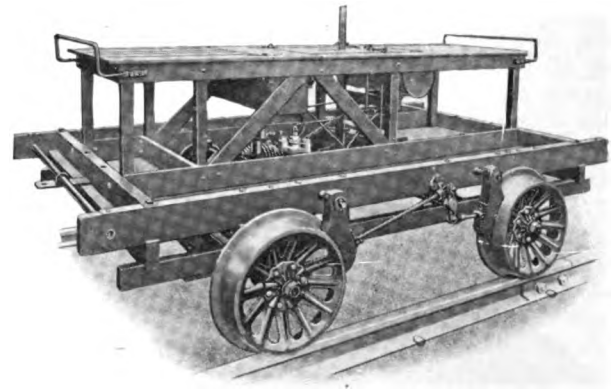
Where good, sound hand or push cars are now in service, they can be transformed quickly, with the Mudge "Wonder Pull" into first-class section cars. In addition to the complete frame and engine with all the parts assembled, a 14-in. diameter split steel pulley and 3½-in. belt are furnished. The equipment is located on the car directly over the center sills and with the bolts supplied is fastened securely to the longitudinal cross sills. The work of mounting can be done in a short time and by an unskilled workman.



Mudge "Wonder Pull" Class GQ-2

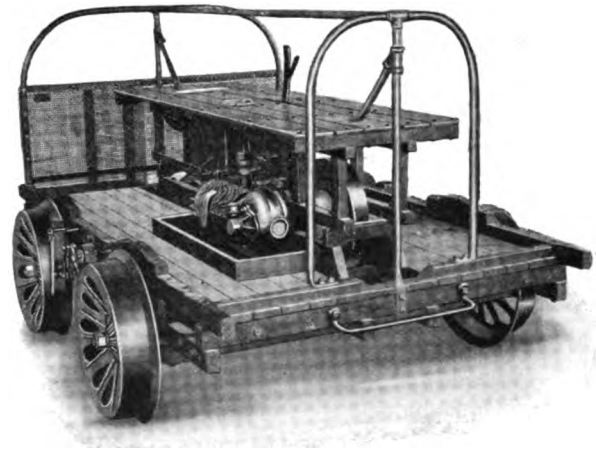
"Heavy Duty" Extra Gang Car Class GS-2

For extra gang service, in which as many as 30 or 40 men are to be carried on trailers, or for sections located in territory subject to heavy winds, or where grades are unusually heavy, a car of high power is required. The power plant of the "Heavy Duty" car is composed of two complete engines, each having its own Mudge carburetor and set of control levers, which permit the use of one engine at a time if desired.



Mudge "Heavy Duty" Class GS-2

This makes for economy of operation, which is an important feature in a car employing two large cylinders. For a heavy duty car the class GS-2 is light in weight, and is handled easily on and off the track. The car operates equally well in either direction.



Mudge "Light Section" Class GS-4

"Light Section" Motor Car Class GS-4

The "Light Section" single-cylinder car is not intended for long runs or for carrying heavy material, but mainly for carrying men and tools to and from their work on sections of average length. The power is transmitted by a belt which is tightened or slackened at the will of the operator by means of a lever which extends up through the seat board and carries an idler pulley. The car is generally equipped with safety railings which have a heavy screen guard at the front, preventing dangerous loading and keeping tools from falling off. These railings, which are patented, can be applied to all Mudge cars or to any other make of car. They supply a dependable protection to the men from being thrown off the car when it is brought to a sudden stop. All Mudge Motor Cars are insulated.

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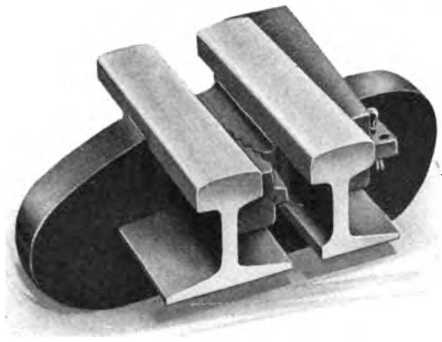
GUARD RAIL CLAMPS AND RAIL BRACES

General

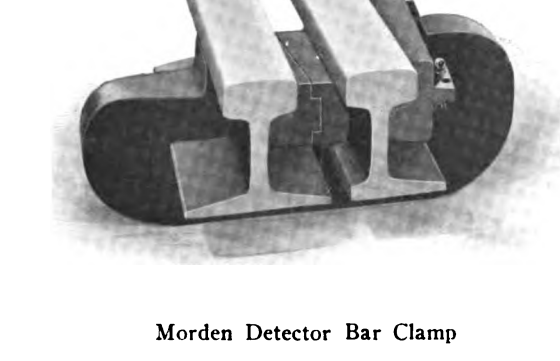
The Morden Frog and Crossing Works, Chicago, is a manufacturer of frogs, switches, switch stands, crossings, guard rails, guard rail clamps, compromise joints, tie bars, rail braces, and other track specialties, and of all kinds of standard or special track work for steam, electric and industrial railroads, being one of the oldest manufacturers of special track work in the Middle West. Established by Wm. Morden 40 years ago, the company has grown steadily with the increased use of its products until it is today a concern of imposing proportions, with a thoroughly modern and complete plant occupying fourteen acres. It includes a department devoted specially to manganese steel track work, and is equipped to handle all ordinary rail construction from 16-lb. rail up to heavy frogs and switches of 130-lb. section.



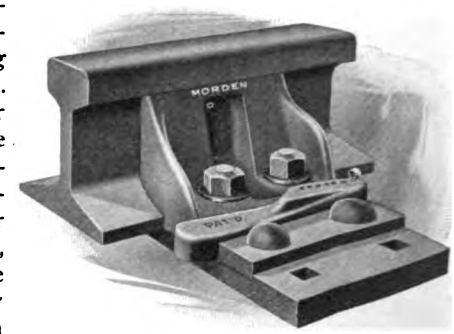
Guard Rail Clamp

Adjustable Guard Rail Clamps

One of the products of this company to which special attention has been given is the Morden adjustable guard rail clamp, which has been in constant and extensive use throughout the country for 15 years. This clamp is of two types, the Standard type, for ordinary use, and the Detector-bar type, designed to meet the requirements in terminal yards and at other points equipped with switch locking detector bars. Each type of clamp consists of a massive wrought iron yoke, a malleable adjusting wedge, and two malleable iron filler blocks, heavily ribbed and reinforced. The yoke of the Detector type of clamp, the only point wherein the two types differ, has one end forged down to give the necessary clearance for the detector bar without loss of strength. The clamps are applied by simply slipping on the yoke, inserting the filler blocks, and driving in the wedge without disturbing the guard rail. Vertical displacement of the wedge is prevented by the rib which engages a slot in the yoke, and it is prevented from slipping out by its shape and by a cotter key inserted in one of several holes provided in one end. Both the yoke and wedge fit the fishing section of the rail accurately, thus preventing any rocking or overturning movement. The filler blocks are wedge-shaped, mortise together lengthwise, and have either saw tooth or plain faces. The clamps are practically indestructible. They permit of about ¾ in. adjustment and have all parts interchangeable. One clamp is generally sufficient for an 11 ft. guard rail, two for 15 ft. lengths.



Morden Detector Bar Clamp



Adjustable Rail Brace

Adjustable Rail Brace

Another Morden product which is widely used is the Morden adjustable rail brace which is designed to meet the need for a simple and effective means of maintaining the proper track gage at slip or split switches. This need is especially pronounced on track subject to continuous travel of fast and heavy trains, as the ordinary rail brace provides no means of taking up the unavoidable wear occurring between the brace, rail and plates. Aside from taking up this wear the Morden adjustable rail brace can often be employed to advantage during initial construction, particularly in slip switch work or at terminals where time is limited. It is well adapted for use also in interlocking switches by insuring the close adjustment required by interlocking mechanism. The brace is of high grade malleable iron and consists of the brace proper, and the wedge which bears against any form of stop or abutment on the plate. The brace is held to the plate by two bolts or lag screws, the bolts passing close to the rail flange to insure a positive clamping action on the rail. It is forced against the rail simply by driving the wedge between the toe of the brace and the stop block on the plate. The brace can be installed, adjusted, and renewed without disturbing the rail, tie or plate. No lateral adjustment is required and the brace always maintains its position properly centered on the plate. The wedge mortises into the brace and is secured against slipping out by a cotter key. The stop block is square with the plate and brace, insuring the brace from backing off should it become loose.

Rail Brace Parts

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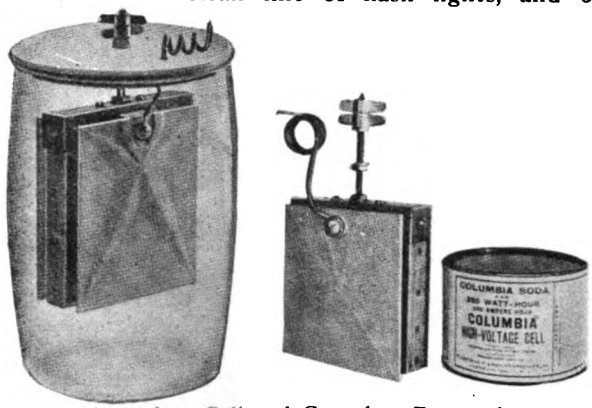
General

The National Carbon Co., Inc., Cleveland, Ohio, and San Francisco, Cal., together with the Canadian National Carbon Co., Ltd., Toronto, an associated company, is the manufacturer of the Columbia Track and R. S. A. High Voltage Signal Batteries, the Columbia Ignitor, and the Red Label, Hot Shot, and Multiple Dry Batteries, widely used on American and Canadian railroads in signal and interlocking service, for telephone and telegraph work, crossing alarms, call bell systems, gas engine ignition, etc. The company is also the manufacturer of Columbia Storage Batteries, the American line of flash lights, and of



Complete Cell and Complete Renewal.

a large number of carbon products, chief among which are Columbia Pyramid Brushes for motors and generators, and Columbia carbon, paste, and blocks for welding work.

Columbia R. S. A. Batteries

The Columbia Track and R. S. A. High Voltage Signal Batteries are of the soda type, a solution of caustic soda comprising the electrolyte and elements of zinc and copper-oxide, the electrodes. In the Columbia Track Batteries, the zinc electrode is cylindrical and is suspended from the top of the jar. The oxide is placed on a tinned disc in the bottom of the jar and acts jointly with the zinc in generating the current and also serves as the depolarizer.

These batteries can be used in any service not requiring a constant drain of more than 500 mil amperes. They are made with a capacity of 400 ampere hours and yield a working voltage of 0.66. Although largely superseded by the Columbia R. S. A. High Voltage batteries, they are still furnished to railroads in large quantities and are preferred in some classes of service by virtue of their relatively high and constant internal resistance. Where no external resistance is employed and short circuiting is encountered frequently this internal resistance insures a battery life of at least three or four months.

The Columbia High Voltage Batteries are the result of the Company's effort to meet the need for cells retaining the many desirable features of soda batteries but capable of yielding a higher voltage. This need was felt particularly in track circuit work where the use of soda cells in circuits originally designed for gravity cells was often attended by much wastage of available energy owing to arrangements in cells made necessary to secure a voltage as high as that furnished by the gravity batteries.

When discharging at the rate of one ampere, each cell yields a voltage of 0.83. This increases with a decrease in discharge and at 200 mil amperes reaches 0.87 or 0.88, the voltage for any rate of discharge maintaining itself relatively constant regardless of temperature changes, a feature of much importance where batteries are exposed to cold weather. This voltage, about 20 per cent higher than that of the ordinary soda cell and practically the same as the average yield of the gravity cells, occurs as a result of the presence of a small quantity of a special chemical in the copper oxide element, the oxide in these cells serving only as the positive pole and as the depolarizer. This chemical also permits the use of 600 amp. hr. renewals in R. S. A. jars without appreciable loss of efficiency, the larger capacity cells often affording distinct advantages inasmuch as they require less frequent renewing. By reason of this high and relatively constant voltage there is often afforded the opportunity of reducing the number of cells required in a battery.

The cells are simple in construction. The copper oxide, in flake form, is carried in a perforated container which is held rigidly between two zinc plates with the element suspended from the cover by a single rod which also serves as the positive terminal of the cell. They are preferably set up hot, thus avoiding the resultant delay where the solution must first be allowed to cool after incorporating the caustic soda. The renewal is self oiling, thus eliminating the handling of oil separately, and the construction of the zinc plates is such that indication of approaching exhaustion is provided in plenty of time to allow renewals to be made before a reduction occurs in the efficiency of the cell. By virtue of their low and relatively constant internal resistance, about 0.019 ohms, the batteries are distinctly adapted for heavy discharges, although where heavy discharges are not desired, suitable control is effected simply by inserting external resistance in circuit.

Columbia High Voltage renewals are made in 300, 500, and 600 amp. hr. capacities. The 300 amp. hr. renewals, in a 2⅞ by 5¼ by 10-in. rectangular jar, is particularly adapted for telephone service. The 500 and 600 amp. hr. renewals in the R. S. A. 6 by 10½-in. cylindrical jar, the 6-in. by 9¾-in. barrel-shaped jar, and the 5 by 6 by 10-in. rectangular jar, are adapted to the heavier service. Portable trays can be furnished for rectangular jars.

Columbia Hot Shot Battery

In the Columbia Hot Shot Battery, railroads are provided with the means of avoiding much of the depreciation and annoyance attending the use of dry cells where subject to the rough usage and exposure common to motor cars. These batteries consist simply of a set of Columbia dry cells connected together except for the two extremities, embedded in a nonconducting and water-proof composition, and enclosed in a fiber case equipped with a handle and two binding posts. The cells, being of the same date of manufacture, exhaust at the same time, and are protected from exposure, breakage, short circuiting, and loosening of connections. They are made in 21 types, for all kinds of service.

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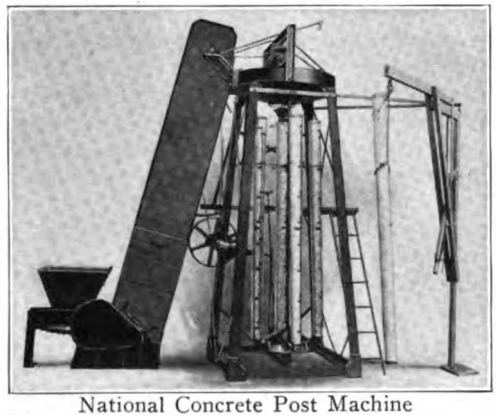
CONCRETE POST MACHINERY AND TIMBER DAPPER

General

The National Concrete Machinery Company, Madison, Wis., is the manufacturer of the National Concrete Post Machine and the National Steel Molds for the making of reinforced concrete fence posts and the Toohey Timber Dapper for notching bridge ties, guards, etc.

Concrete is rapidly coming into use as a material for fence posts, having the advantages of wood posts without many of their disadvantages. They are inexpensive because they may be made principally of materials which are obtained locally, and are durable because of their immunity from destruction by fire, frost, weathering or decay. The National concrete machinery is designed for the quick and economical manufacture of posts of this material. Over a million National concrete posts are now in use in right-of-way fences throughout the United States and Canada, such leading roads as the Burlington, the Illinois Central, the Rock Island, the Big Four, the Central of Georgia and the New York Central, using National machines for this purpose.

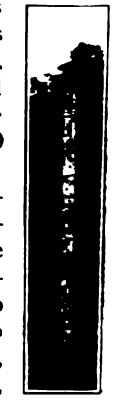


National Concrete Post Machine

The National Concrete Post Machine

The National concrete post machine, which is designed to make posts economically and rapidly, is a power machine which runs practically automatically. To operate the machine, sand is placed in one section of a divided hopper and cement in the other. The material is then moved to the boot of the elevator by an apron belt. A gate with a screw adjustment, mounted on the cement side of the hopper, controls the flow of cement. As the apron belt leaves the sand section of the hopper it carries upon it a layer of sand on top of which a layer of cement is deposited while passing through the cement section. The material is elevated in buckets from the boot to the upper part of the machine and is thrown on the outer portion of the mixing bowl where it is mixed to the proper consistency by four sets of rotary plows. It is then moved to the center of the bowl, and the correct amount of water applied by a sprinkling pipe located above the plows and regulated by a valve within convenient reach of the operator. The molds are filled under the center of the mixing bowl, the flow of concrete being controlled at this point by a gate.

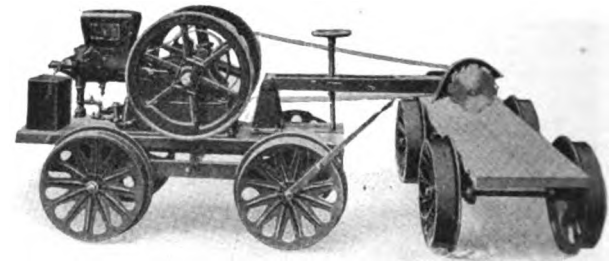
Two sizes of machines are manufactured, one for making posts up to 8 ft. in length, and the other for making posts up to 10 ft. in length. Line, corner, gate or brace posts, and of the particular size desired, can be made in the machines simply by inserting the appropriate mold. This affords flexibility in the manufacture. These posts are round and taper from top to bottom, thus having the greatest volume of material in the base where strength and size are needed. Under ordinary conditions from 60 to 90 days are required for curing.



The National Steel Molds, made from galvanized sheet steel, light in weight, yet having sufficient strength for long service, are mounted on a turntable rack for filling. During the time of filling, which is from 40 to 50 seconds, the mold is jostled, or moved up and down in the path of the falling material, so as to obtain a filling uniformly packed, the lever for this movement being actuated by a cam on the driving shaft of the machine. As each mold is filled the turntable rack is revolved, bringing the next empty mold into place. The reinforcement, consisting of six strands of No. 8 bright Bessemer steel wires, placed to conform with the cylindrical shape of the post and held in position by four bond wires, is set in the mold before filling and affords the post a maximum tensile strength. Each mold is equipped with a cast iron cap which forms the top of the post and serves to center the reinforcement. By means of removable pins inserted in the mold, holes are provided in the post for the fastening of the fence wires.

The Toohey Timber Dapper

The Toohey Timber Dapper, another product of the National Concrete Machinery Company, is a complete power-driven unit for squaring and dapping, by a rotary saw and cutter, stringers, ties, and guard rails used in railway bridge construction, and is likewise adapted to squaring, gaining, or dapping the sills, beams and other timbers used in railway car building and car repair work. The cutting unit, with a means of adjusting it to the required depth of cut, a means for moving the cutter back and forward over the timber and the



The Toohey Timber Dapper

driving power, usually a gasoline engine of 3 hp., is mounted on a truck of 24-in. gauge. This truck is located on a track which may be of T rails, angle iron or timbers, placed within convenient working distance of the pile of lumber to be formed. This timber is brought to the cutting unit on a second truck of the same or standard gage. The operator of the machine passes the cutter back and forth over two ties at a time, this movement being accomplished by means of a lever attached to one of the forward wheels of the truck on which the cutter is mounted. A sheet steel guard protects the operator from flying chips. The cutting head can be removed from the driving shaft and replaced by a cut-off saw for timber cutting.

THE NATIONAL CONCRETE MACHINERY CO., MADISON, WIS.

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General

The National Lock Washer Company, Newark, N. J., is favorably known for its manufacture of Hipower Nut Locks which serve, by the large pressures they exert, to diffuse the shocks of traffic, compensate for the small but unavoidable wear of the bolted parts and avoid as far as can be done mechanically the permanent stretching of the bolts.

The Hipower Nut Lock

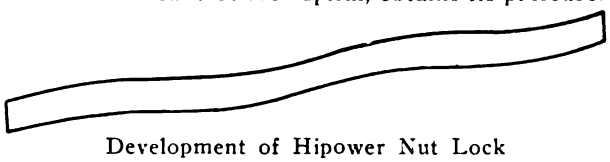
These nut locks were introduced in 1914 to meet the need for increased strength of the joint fastening and are now used in large numbers by most of the railways of this country and Canada. Approximately 100,000 Hipower nut locks are produced daily and the output in one year is sufficient to equip a track encircling the globe.

The National Lock Washer Company, which was established in 1886, has its main office and factory in Newark, N. J. and maintains branches in New York, Chicago and Detroit, Mich. The company manufactures all types of nut locks, including, in addition to Hipowers, the plain type, frog and switch collar nut locks, tail pattern nut locks and the familiar National Rib Lock Washers, of which it was the originator and which are so widely used in connection with rolling stock.

The Hipower Nut Lock

Recognizing the need for the greatest possible reactive force of the nut lock, equal at least to the elastic limit of the best steel available for bolts, the National Lock Washer Company undertook to devise a nut lock (1) that would, at reasonable cost, provide permanent and adequate pressures to hold the angle bars to the rail, although not so tightly as to impede expansion, and (2) in which the force would be exerted on lines parallel to the axis of the bolt.

The Hipower nut lock, finally developed in the form of a concavo convex spiral, obtains its pressures



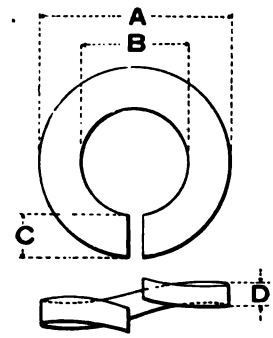
Development of Hipower Nut Lock

by the combination of the resistance of the spiral deflection, the curved deflections upon the spiral and the torsional deflection. The last element, existing also in the plain spiral, is accentuated in the Hipower nut lock by the curved deflections. The entire device while under compression functions to provide a seat for the nut at three points, with a corresponding bearing upon the backing. The width of the Hipower brings its outside diameter to the long diameter of a U. S. standard square nut, affording the fullest possible frictional bearing as well as such transverse strength as to prevent the device spreading upon the removal of the nut.

Duty of Hipower Nut Locks

The railways have come to a fuller realization of the importance of keeping all bolted parts of the track structure tight, and they appreciate also the necessity for a means of compensating for unavoidable looseness caused by the small but continual natural wear. The enormous weight and recurring impacts of rolling loads cause movements of the track joints which produce a grinding wear that must be provided for. Failure to do so results in progressively increasing looseness of the bolts, which in turn causes low joints, battered rail ends and deformed splice bars.

Hipower nut locks, through their extreme reactive power, proved by actual test to approximate 12,000 lb. in the 1 in. size, and also through the resilience effected by their use, retard the development of this looseness, enabling the orderly processes of maintenance to correct the loose bolts without injury to the joints. With their aid the splice bars are held in secure and uniform contact



APPROXIMATE NUMBER OF HIPOWER REQUIRED PER MILE OF TRACK	SIZE	EFFECTIVE PRESSURES IN POUNDS	DIMENSIONS A DIAMETER OUTER	DIMENSIONS B DIAMETER INSIDE	DIMENSIONS C WIDTH	DIMENSIONS D HEIGHT	NUMBER PER KEG	APPROX NET WEIGHT PER M LBS.	WT. OF KEG LBS	NUMBER OF HIPOWER REQUIRED FOR A MINIMUM CAR LOAD
	3/4"	6000	1 27/64"	53/64"	3/8"	3/8"	2500	72	10	462000
33 RAIL - 4 BOLT SPLICES 1280	7/8"	8000	1 57/64"	31/32"	3/16"	13/64"	2000	109	10	328000
33 RAIL - 6 BOLT SPLICES 1920	1"	10000	1 31/32"	1 1/32"	7/16"	1/32"	1500	122	10	263000
30 RAIL - 4 BOLT SPLICES 1408	1 1/8"	12500	2 5/32"	1 5/32"	1/2"	15/64"	1000	150	10	206000
30 RAIL - 6 BOLT SPLICES 2112	1 1/4"	15000	2 9/32"	1 9/32"	1/2"	1/4"	1000	186	10	178000

Data for Hipowers

with the rails, insuring safe, comfortable and quiet riding qualities in the track.

Manufacture of the Hipowers

The resistance provided in Hipower nut locks requires the use of steel of high strength and uniformity. The specifications for the steel include a tensile strength of 120,000 lb.. and an elastic limit of 80,000 lb. Each heat is passed upon through samples subjected to complete treatment and test to ascertain the character of the reaction, the toughness and the mechanical qualities. The method of hardening and heat treating is an exclusive feature of the manufacture and has received approval from the highest engineering authorities.

As a final test of Hipowers every piece, before leaving the factory, is passed under a 20-ton blow. This test, in addition to the care in the manufacture and in the selection of the material insures, the uniform efficiency of the device. A test of the Hipower nut lock of 7/16 in. by 7/32 in. section, coiled to pass a 1-in. rolled thread bolt, which was made at the Testing Materials Laboratory of Purdue University, showed that the two nut locks tested became flat at 12,000 and 13,000 lb. with a total deformation of 0.104 and 0.099 in., respectively.

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Water Main Cleaning

Water main cleaning processes which have as their object the cleaning of pipes while in place and which are directed not only to the removing of debris and other loose material but also the firmly adhering, tubercular growths and cement-like incrustations, have attracted a great deal of attention from railroads since they have become established on a practical and economical basis.

Processes of this kind are of interest chiefly because of the relief they offer as a means of post-

Cross Section of Incrusted Pipe Showing a Condition Often Encountered in Water Main Cleaning

poning or of eliminating the need of costly water line renewals and of removing various ills commonly encountered at points where water lines are obstructed. Practically all roads are forced to use waters at some points which give rise to incrustation of the mains. Often this incrustation consists of sand and clay, carried in and deposited by silt bearing waters. More frequently the incrustation is brought about by the deposition of precipitates resulting from deficient water softening processes, the precipitates distributing themselves uniformly over the pipes and often giving rise to formations difficult to remove by chiseling. The rapidity with which this incrustation may occur is indicated by the practice of some roads of cleaning the mains at certain stations as frequently as every three years. In any event, such incrustation which is taking place in the pipe line, unless removed, eventually renders useless, pipe, which, if of cast iron, would otherwise last indefinitely, and in the meantime gives rise to the expense and annoyance entailed by the blowing out of pipe joints or pump packing under the excessive pressure consequent on forcing water through obstructed openings, also the over-loading of power units, breaking of pumps, etc. In the light of the consistent success which has attended the application of the water cleaning processes in recent years, it is natural that the roads have availed themselves of them, as well as the municipalities and other large water users which have experienced like trouble from obstructed water lines.

The National Process

The National Water Main Cleaning Company, New York City, was established in 1906 as the successor to the Hudson Contracting Company and is the owner of its patent rights, equipment, etc. Since its organization the company has devoted its attention entirely to the cleaning of water mains and to the improvement of pipe cleaning methods and devices. With the equipment in its present state of perfection and the wide experience acquired in this kind of work, the company is prepared to handle any water main cleaning problem involving pipe 4 in. or more in diameter.

The company operates all over the United States and Canada, and has cleaned many miles of pipe for numerous railroads, including the Atchison, Topeka & Santa Fe, the Baltimore & Ohio, the Chicago & North Western, the Illinois Central, the Missouri Pacific, the Pennsylvania, the Great Northern, the Seaboard Air Line, the Cleveland, Cincinnati, Chicago & St. Louis, the New York Central, and the Chicago & Eastern Illinois. It is significant that later contracts have been made with the company by these roads after observing the results obtained on the first work.

The devices employed are of different designs for pipe of various sizes, but consist essentially of a series of scrapers and piloting or propelling discs, flexibly connected, one behind the other, and of such designs as to permit their being forced through the pipe by water pressure or, where sufficient pressure is not available, of being drawn through by cable. When water pressure is available, a turbine type of cleaner is used and the method of cleaning consists of cutting the main at two predetermined points, inserting the device at the initial point, sealing the opening by inserting a temporary section of pipe, and after inserting a riser pipe section at the other point, applying the water pressure, all scrapings being washed ahead of the machine and forced out at the riser pipe by that portion of the water which is allowed to pass the propelling discs. The other method consists of drawing the device through the pipe by a cable operated by a windlass, water also being used in this operation for flushing out the scrapings.

The length of pipe line that may be cleaned by the machine at one time varies from a few hundred to several thousand feet, depending upon the size of pipe, the amount of incrustation, the method employed, the number of bends, etc. The company guarantees that where mains were tar coated or dipped when installed, it will restore their carrying capacity to at least 95 per cent of that of new mains, the 5 per cent allowance being made for irregularity in laying pipes.

Among the advantages of this method, aside from its effectiveness and cheapness (the cost being a matter of a few cents per foot), are the rapidity with which it can be performed and the fact that pipe lines, if not in service continuously throughout the day, may often be cleaned without necessitating the installation of a temporary water line.

NATIONAL WATER MAIN CLEANING COMPANY, NEW YORK CITY

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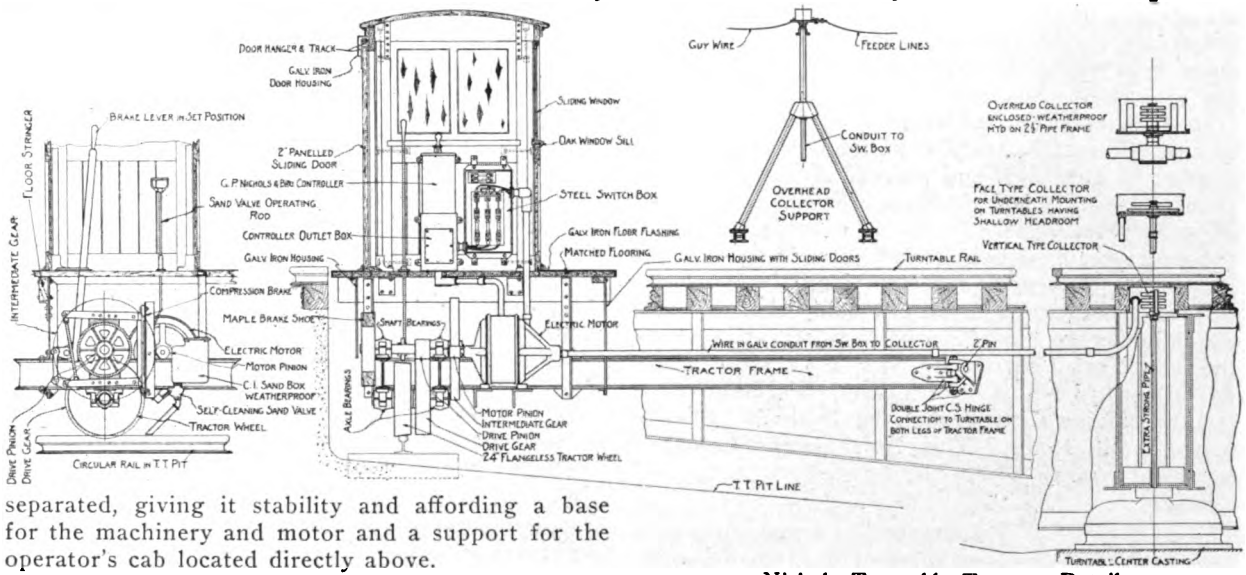
Nichols Turntable Tractor

The Nichols Turntable Tractor is a single-wheel locomotive, flexibly attached to the end of the turntable, the traction wheel, which carries almost the entire load, running on the circular track usually provided in the pit for the end trucks of the table. It is driven through a train of spur gears by a motor, usually electric—sometimes gasoline—sometimes air. The axle being radial the wheel tends to travel in a true circle without side-slipping. The adjustable cast steel hinges which attach the tractor to the turntable are widely separated, giving it stability and affording a base for the machinery and motor and a support for the operator's cab located directly above.



Nichols Turntable Tractor—Details

The above diagram shows the arrangement of the essential parts of the tractor equipment and the simplicity and ease of access for inspection and repairs. All bearings have removable caps. The manufacturers have always advocated the use of a single drive wheel. For a given weight no greater tractive effect can be secured by increasing the number of drivers, and the use of more than one introduces disproportionate mechanical disadvantages with correspondingly greater difficulty of maintenance.

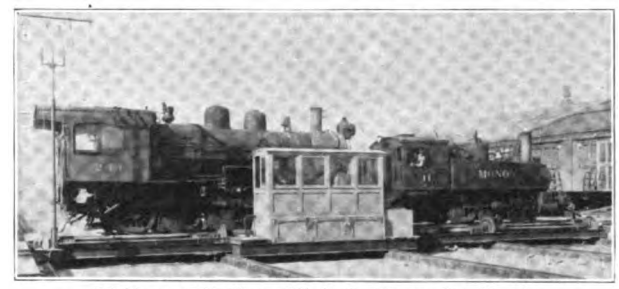
Nichols Tractor on 100-Foot Turntable

The effectiveness of a tractor depends primarily upon the weight on the drivers. Three capacities of tractor are offered: the Standard, Intermediate, and Extra Heavy Type, which may be counterweighted to 11,000 lb., 15,000 lb., and 24,000 lb., respectively, and with motors suited to the service expected.

Geo. P. Nichols & Bro. have built turntable tractors for 20 years. Every part is standardized, which simplifies maintenance and makes immediate shipments of new tractors or maintenance parts possible. More than 100 railroads use the Nichols Turntable Tractor.

Nichols Transfer Table

The Nichols Transfer Table is a thoroughly standardized machine, designed to move cars or locomotives from one cross track to another, and equipped with a winding drum attachment for pulling its loads onto or off from the table. It consists of a rigid structural steel frame carried on wheels running on two or more rails, usually in a pit. The moving power is electricity, one motor being used to propel the table or to pull the load, as may be desired. Selective friction clutches, interlocked with each other, are provided, making it impossible to perform both functions at one time. When the pit is a long one, two gear ratios are used, one for moving the loaded table at a slow rate and the other for moving the table empty or with small load at a high rate. Great strength and rigidity are required in the frame to prevent lateral distortion and to insure straight travel, and at the same time enough flexibility to enable the table to adapt itself to the irregularities in the pit rails, which may occur. All the wheels are straight tread, with flanges, those on the driving side being ground to exact uniform circumference and coupled into one continuous driving shaft running the entire length of the table. Each wheel can be uncoupled and removed without dismantling any other part of the table.



75-Foot 265-Ton Nichols Transfer Table

The operator's cab is directly above the machinery, giving the operator a view over the whole table. Current is taken from either an overhead trolley line or from trolley wires running along the side wall of the pit. Eighty-five railroads and car builders use Nichols Transfer Tables.

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General

The Northeastern Company, Boston, Mass., is a manufacturer of a wood preservative of its own derivation. It also prepares anthracene oil, creosote oil, and dead oil of coal tar according to specifications. The company's wood preservative is manufactured under the trade name Letteney. This product has been on the market since 1867, during which time it has been largely used by railroads, builders, the U. S. Government, and industrial concerns for the preservation of structural timber, railroad ties, fence posts, telegraph and telephone poles, wharf timbers and piles, bulkheads, conduits, paving blocks, etc.

LETTENEY
WOOD PRESERVATIVE

In advancing the merits of this preservative the company directs attention particularly to a large number of municipal and railroad structures in and about Boston, some of which are still in use after 20 to 30 years' service; while in other cases, where the structures have been rebuilt after 18 to 33 years' service, the treated timbers were found in a satisfactory state of preservation. Among the railroads which have used this preservative in recent years are the New York Central, the New York, New Haven & Hartford, the Boston & Albany, the Illinois Central, the Maine Central, and the Nashville, Chattanooga & St. Louis. The Northeastern Company maintains branch offices in New York City and Chicago.

Letteney

Letteney is a liquid compound manufactured from by-products of wholly bituminous coal tar, and is guaranteed to contain at least 99.5 per cent of pure coal tar oil. It distills only at high temperatures and contains no volatile matter. In its composition it conforms to the following specifications:

Completely liquid at	38 deg. C.
Specific gravity at 38 deg. C.	1.09 min. 1.13 max.
Burning point	165 deg. C. min.
Residue insoluble in hot benzol.	0.25% max.
Contained water.	1% max.

When distilled by the method specified by the American Railway Engineering Association, the oil, calculated on the basis of dry oil, will pass the following tests:

Distillate below	270 deg. C. 2% max.
Distillate below	300 deg. C. 20% max.
Residue above	360 deg. C. soft at 20 deg. C.
Tar acids in fractions below 300 deg. C.	2% max.
Sulphonation residue from fractions between 300 deg. C. and 330 deg. C.	0.25 c. c.

When applied to wood it penetrates readily and, not being soluble in water, will remain in the treated wood indefinitely. Owing to this characteristic, together with other physical properties, it is adapted to brush, open tank, and spray treatments. The color is a permanent dark red brown. The Northeastern Company furnishes the preservative in 50-gal. barrels, drums, ½ barrels, and in 5 and 10-gal. cans.

Application

The Letteney Wood Preservative, when applied by the brush, open tank, or spray method, is used according to the following specifications:

Preparation. In all cases the wood should be as well seasoned as possible, all bark removed prior to treatment, and any accumulation of dirt or other foreign matter on the timber scraped off with a wire brush.

Brush Treatment. When the wood is dry, make two applications of Letteney Wood Preservative, applying thoroughly with a broad, flat, stiff bristle brush, making the second application after the first has been absorbed, and keeping the temperature of the preservative between 175 deg. and 210 deg. F. while applying.

Open Tank Treatment. After cutting and fitting, all lumber shall be completely immersed for 20 min. in a tank containing Letteney Wood Preservative, which must be maintained at a temperature of from 175 deg. to 210 deg. F.

Spraying Treatment. This treatment shall consist of one heavy spraying with Letteney Wood Preservative, heated to a temperature of approximately 175 deg. F. Surfaces must be thoroughly covered and treatment given to the refusal point when spraying seasoning checks, joints and contact surfaces.

Covering Capacity

The approximate covering capacities of the Letteney Wood Preservative, when applied to rough and dressed lumber by the brush, open tank, and spray treatments according to good practice, are as follows:

	On Rough Lumber	On Dressed Lumber
2 brush coats 20 minute dip, or sprayed	100 sq. ft. per gal.	150 sq. ft. per gal.
1 brush coat	150 sq. ft. per gal.	300 sq. ft. per gal.

West Shore Railroad Pier, Weehawken, N. J. All Timbers and Planks Treated with Letteney

THE NORTHEASTERN COMPANY, BOSTON, MASS.

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General

A. O. Norton, Inc., is the manufacturer of the Norton Self-Lowering High-Speed Jacks for locomotive and car work, bridge repairs and general lifting purposes, with capacities ranging as high as 100 tons; the Norton Ball-Bearing Ratchet-Screw Jacks, without the self lowering feature, in types designed especially for bridge and wrecking service, for locomotive work and for general lifting work; the Norton General Purpose Jacks, equipped with cone-bearings in place of ball-bearings; and a complete line of track jacks of both the trip and automatic lowering patterns, and in the two capacities commonly used, 10 tons and 15 tons.

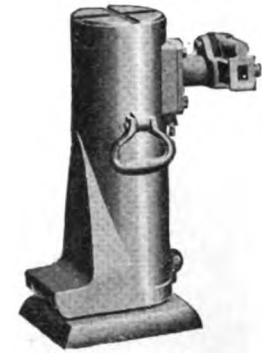
A. O. Norton, Inc., was established in 1886 and has thus been engaged for over 35 years in the manufacture of the single item of railway equipment-jacks. Norton jacks have been adopted as a standard tool by 90 per cent of the leading railroads, on which their quick action, along with entire safety and the maximum of reliability, have caused them to be valued highly. The record of Norton jacks under the most exacting conditions has justified the confidence placed in their performance. The maker further fortifies this confidence by an absolute guarantee of the jacks in every respect.

The general office and works of A. O. Norton, Inc., are at Boston, Mass., its Canadian works being at Coaticook, P. Q. Foreign offices are maintained at London, Eng., and Glasgow, Scotland.

Norton Bridge Jacks

The Norton Jacks of chief importance in maintenance are the ball-bearing ratchet-screw jacks specially designed and constructed for use in bridge work, but applicable also to general lifting as well as wrecking work. The increased speed is desired, and that on the lower shaft when the full power of the jack is required. These jacks have a total rise of 11 in. The 50-ton bridge jack is made for rises of 9 in. and 12 in. The 15-ton jack has a rise of 10 in., and the 25-ton and 35-ton jacks are made for 10-in. and 13-in. rise. Repair parts for all these jacks may be obtained by giving the number of the part with the style of jack, obtained from its plate.

10-In. Jack
25 Tons

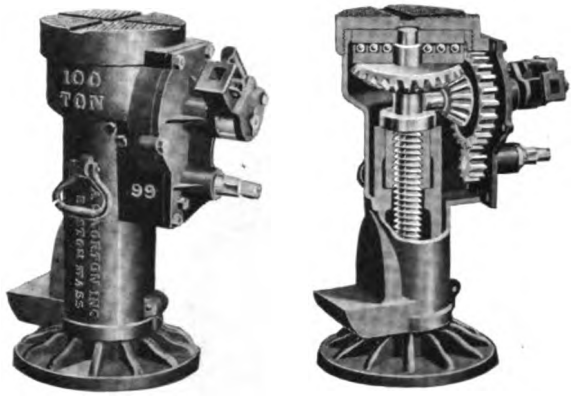


22-In. Bridge Jack
25 Tons

Self-Lowering Trouble-Proof Jacks

An improvement over the original Norton Jack has now been made by which the jacks are actually self-lowering without the use of lever or crank. By pressing a lowering cam the full load is quickly, easily, and safely lowered without any effort.

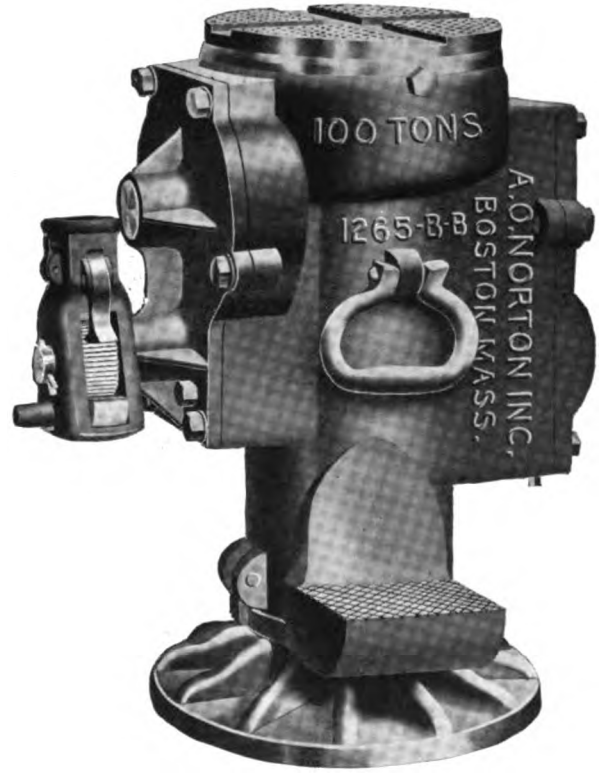
Perfect speed control prevents it from lowering too fast, and makes it absolutely safe. The improved jack is known as Series "BB" and is made in a variety of styles, both plain and with foot-lift, and in capacities from 25 to 100 tons.



Norton Ball Bearing Bridge Jack

Norton ball-bearing jacks have gears of solid steel forgings, machine cut. The gears are kept in perfect adjustment by means of a set screw underneath the cover. This line of jacks is made from the best materials and the indicated capacity is guaranteed. This is always the head lift and no more than half the amount should be raised by the foot in any case.

The jacks of 70- and 100-ton capacity, which are designed for extra-heavy bridge work, are compound geared, the ratchet on the upper shaft being used when raising a light load, 30 to 40 tons, where



Self-Lowering New Series "BB"

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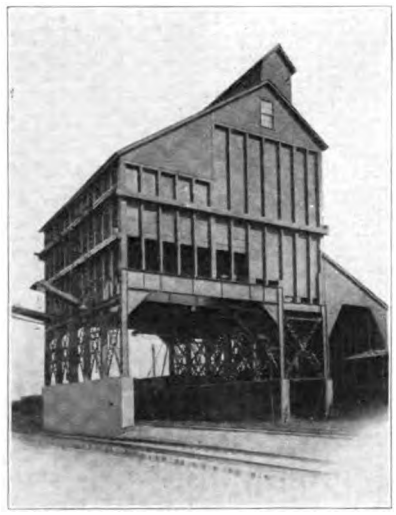
General

It may be said that a coaling station is relatively of little consequence when it functions properly, but that it is one of the most important things on the railroad when it is out of service, when it is limited in its capacity to meet the service required, or when the cost of performing that service is excessively high. The main purpose of the Ogle Construction Company since its organization, ten years ago, has been to design and erect locomotive coaling stations capable of fulfilling the requirements of modern service and to equip them with mechanical appliances which would dependably and economically perform that service even under the most adverse conditions. The fact of there being over 300 Ogle Balanced Bucket Coaling Stations now in service on 56 railroads reflects the extent to which this purpose has been accomplished. They are of frame, steel and concrete construction, vary in storage capacities from 50 to 1,000 tons, and deliver one or several grades of coal to one or more tracks. Many of them are equipped with complete facilities for storing, drying and supplying sand.



Frame Coaling Station.
3-Track—800 Tons

The frame station is desirable where initial economy and short erection time are required and where uncertainty exists as to future terminal developments. The bin is usually lined with sheet steel to prevent the falling coal cutting away the interior. In some of the stations, water sprinkler systems have been installed, to reduce the fire hazard. The all steel station costs slightly more than the frame station, is fireproof and can be easily relocated should conditions require it. The permanence, fireproof character and inappreciable maintenance of concrete stations, amply justify their somewhat higher initial cost, particularly at locations where large quanities of coal are handled, and where the probabilities of alteration or abandonment are remote.

All-Steel Coaling Station.
2-Track—300 Tons

Operation of Ogle Stations

In its operation, the Ogle Balanced Bucket Coaling Station is essentially a "One Man" station, since the machinery, after being started, continues to operate automatically and does not require constant attention from the operator. Comparatively little power is required to operate the station, as it has relatively few working parts. The mechanical parts comprise an automatic reversing hoist, an automatic loader and a bucket, each of which is simply designed and sturdily constructed.

Concrete Coaling Station
4-Track—1000 Tons.

The Ogle patented automatic reversing hoist, specially designed for coaling station service, is built in sizes to accommodate buckets from ½ ton to 2½ tons capacity and to provide hoisting capacities ranging from 30 to 125 tons per hour. The automatic features are component parts of the hoist and make a self-contained unit which can be driven by any kind of power. A desirable auxiliary is the winch head fitted to the extended drum shaft, which facilitates prompt spotting of the cars over the hopper. Power is applied continuously in one direction, and is transmitted through friction clutches and reduction gears

Ogle Bucket.

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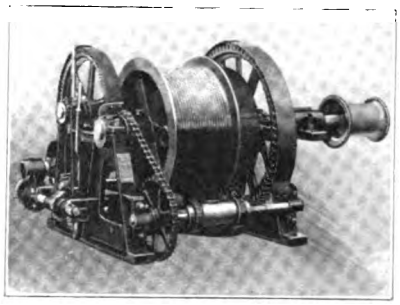
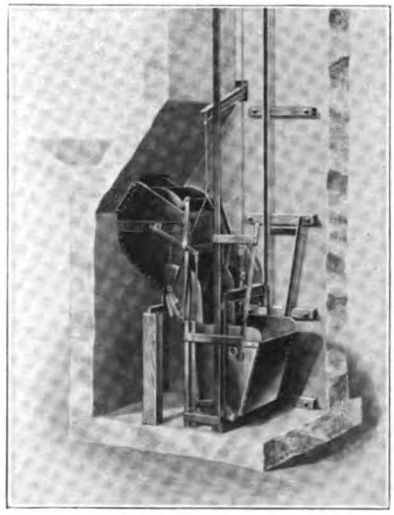
to the drum. A steel cable leads from the drum to the bucket. The loaded bucket is elevated to the top of the tower and, as the load discharges into the storage bin, a limit lever on the hoist automatically releases the clutch, stops the travel of the drum and holds the bucket in the dumping position sufficiently long to empty it. An automatic reversing mechanism then comes into operation, engages the clutch geared to the reversing shaft and reverses the travel of the drum, thus lowering the bucket for a recharge. This operation continues without any attention from the operator. Should the power fail, an automatic lock prevents any back travel of the bucket.



Ogle Automatic Hoist.

Bucket installations are single, with a counterweight, or double, with the one bucket counterbalancing the other. In single installations, only one loader is used and is operated jointly by the bucket and a small counterweight. In double installations, two loaders are used and are actuated entirely by the buckets.

As the loaded bucket ascends, it closes the apron of its loader, when the small counterweight or the other bucket, as the case may be, simultaneously locks this apron and opens the radial gate in the rear of the loader for a recharge. The bucket is of the same capacity as the loader and is fitted with shoes to run in vertical T guides or is equipped with flanged wheels to run on an inclined track. Curved guides in the tower completely overturn the bucket for discharging its load. Since latches, triggers or loose doors are not used, the bucket remains a tight container, thereby eliminating any danger of the load being prematurely discharged. As the bucket descends into the pit for reloading, it simultaneously closes the radial gate and unlocks the apron of its loader, cutting off further supply of coal from the hopper and permitting the contents of the loader to flow into the bucket. None of the coal is spilled in the pit, for the bucket is well under the apron when it comes to rest, and it is filled each time. The loader is simply designed, is positive and automatic in operation and like the bucket is constructed entirely of structural plates and shapes.



Ogle Loader Bucket.

The Ogle Coal Spout

The Ogle Coal Delivery Spout is applicable to any type of gravity coaling station, for it embodies the principal features desirable in such an accessory. It is pivoted at the bin, moves laterally 7½ feet, coals all sizes of locomotive tenders at one spotting, and is provided with a breaking joint which prevents damage to the spout or structure, should the locomotive move while taking coal. Compensating weights in conjunction with hooded roller bearing sheaves assure ease and certainty of operation in all weather. The overcut gate cuts with the flow of coal and prevents the firemen skimming the coal, that is, taking all the lump and leaving the slack. The gate is positive in its operation, will not hang up and is easily manipulated from any position on the tender.

The Ogle Spout

At some coaling stations, The Ogle Coal Measure has been made a part of the spout, to measure and record the amount of coal taken by the locomotives. It is manually operated, embodies certain features of the Ogle Coal Spout and the Ogle Automatic Loader, and has proven to be a reliable and economical substitute for scales.

Ogle Service

As each Ogle Coaling Station goes into service, a representative of the Ogle Construction Company remains with the station operator to instruct him in the proper operation, care and adjustment of the machinery, an obligation which the company assumes, to assure to the railroad uninterrupted coaling service. All parts of the Ogle machinery are finished in the shop and require no fitting by hand in the field, each part of one appliance being interchangeable with the corresponding part of another unit of the same size. The stock for new machines serves also as a repair stock, thus making it possible to ship repair parts on short notice at all times.

The Ogle Construction Company maintains a corps of engineers who are experienced in the designing, erection and equipment of locomotive coaling stations that are adapted to the requirements of modern operation and are in keeping with sound engineering practice. The Ogle engineers are entirely at the service of the roads, and are prepared at any time to render expert advice in the solution of problems relating to coaling equipment.

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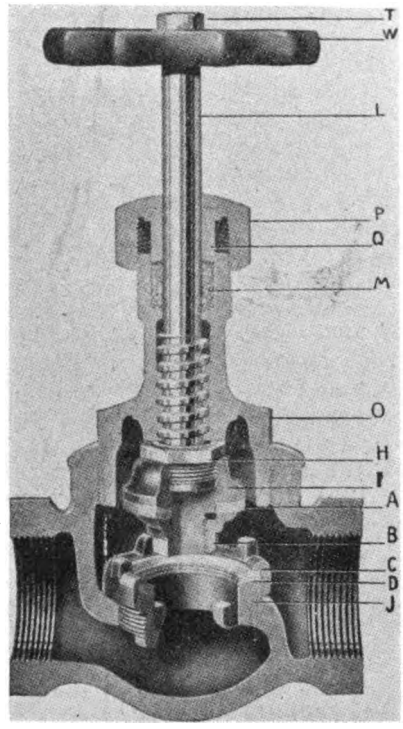
Multiplate Valves

The O'Malley - Beare Valve Co., Chicago, has introduced a line of valves which embody a unique development in valve design and construction. These valves, manufactured under the trade name Multiplate, are designed particularly for use where high temperatures or high pressures are encountered, as in locomotives, power plants, steam shovels, pile drivers, etc., or in other service where the wear is severe, and are the result of the company's effort to produce valves capable of lessening the operating troubles and maintenance expense often encountered. To this end a laminated, or multiplate, construction of the valve heads and seats is employed.



A—Metal plates in head.
B—Disc nut.
C—Retaining ring.
D—Seat plates.
H—Disc ring.
I—Disc holder.
J—Removable master seat.
L—Stem.
M—Packing.
O—Bonnet.
P—Packing nut.
Q—Gland.
T—Wheel nut.
W—Wheel.

Sectional View Multiplate Globe Valve

This construction is the distinctive feature of the valves. In it the heads of all valves and the seats of all but the ¼ in. and ⅜ in. sizes are composed of several thin plates of rolled metal, applied compactly and held securely by clamps in such a way as to form a tight metal-seated valve and yet to permit of easy and quick removal. The plates are about the thickness of the metal ordinarily ground off in the refacing of valve discs and seats and are each of a proper shape to provide a true and tight disc or seat surface. When, therefore, the exposed surfaces in these valves become worn or cut, it is intended that, instead of grinding, the worn plates should be removed and discarded, the valve as a whole being constructed properly to compensate for the loss of the worn plates.

This operation consists of unscrewing the bonnet from the valve body, whereupon the disc plates are made accessible by removing the disc nut on the end of the valve stem. The master seat in these valves, being removable, is then unscrewed from the valve body by inserting a wrench furnished for this purpose between the lugs provided on the inner surface of the seat and unscrewing as one would a nut, after which the metal plates on the seat are made accessible by unscrewing the retaining ring from the master seat. To provide for contingencies where the series of plates become exhausted, and others are not at hand, the master heads and seats of the valves upon which the plates seat, are themselves of a proper shape to serve as valve seats.

This type of construction affords a high degree of durability under the most severe condition and is of particular value in that it lends itself readily to repair. Metal wearing surfaces are employed on the belief that they give the most effective and durable service under the high temperatures and severe service, likely to be encountered by the valves, and the multiplate construction of the seats is justified on the ground that it permits the use of expensive metal in the most economical way, of using the best metal suited to the particular service in which the valve is used without otherwise changing the valve, and of getting a longer life out of a valve subject to rapid wearing or cutting (as in service where valves are kept throttled, subjected to continual opening and closing, or where grit is encountered), than would be possible where solid seats are refaced by grinding.

That there is much in favor of a line of valves which, by making maintenance a simple matter, will afford a greater certainty that the valves in severe and important service will be kept in good repair, is evident. When this is not the case it frequently happens that valves are left to leak until regrinding or renewal becomes an absolute necessity, although the annoyance or other trouble during the time may have greatly exceeded the cost of the repair, particularly where leaky valves are pried or hammered shut, a practice which usually results in broken handles, twisted stems, and premature destruction of the entire valve.

The Multiplate valves are made in globe, angle, cross, check, "Y" and special patterns, threaded or flanged, with brass bodies, iron and wood hand wheels, in medium heavy and extra heavy weights, and in sizes ranging from ¼ in. to 3 in. Medium heavy patterns are intended for working pressures up to 175 lb., and extra heavy up to 250 lb. Valves of ½ in., ¾ in. and 1 in. sizes carry three head plates and two seat plates; those of 1¼ to 3 in. sizes, inclusive, four head plates and three seat plates, and those of ¼ to ⅜ in. sizes, three head plates only. The plates are made of brass, phosphor bronze, nickel, monel, and "O. M. B." metal, or, if specified, of other material.

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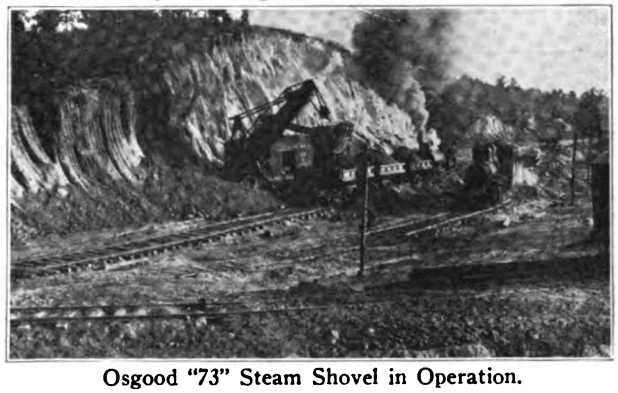
The Osgood Company

The Osgood Company, Marion, Ohio, specializes in the manufacture of excavating machinery for rail and waterway purposes, including steam shovels, ditchers, cranes, clamshell outfits and dredges. The company operates within its own organization both open hearth steel and gray iron foundries, forge, boiler, structural, machine, pattern, carpenter and assembling shops, thus being in a position to control directly the uniformity and reliability of the product at all times. The products of the company are widely used by the leading railroads, contractors, the U. S. Government and industrial companies.

Osgood "18" ¾ yd. Continuous Tread Revolving Shovel.

Steam Shovels

In the manufacture of steam shovels for railway maintenance and construction work, large capacity, ease of handling and low cost of operation and repairs are essential requirements provided for in the principle of design adhered to by the Osgood Company.



Osgood "73" Steam Shovel in Operation.

Osgood ¾ yd. Railroad Ditcher.

Osgood "73" Shovel

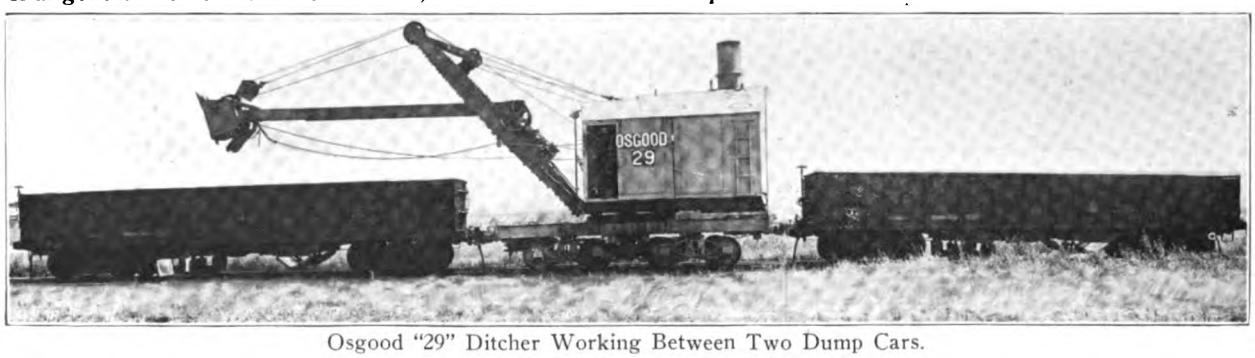
One of the most popular shovels on the market and one extensively used by railroads and railroad contractors is the Osgood "73" 3½-yd. steam shovel. The exceptionally rigid construction of this type of shovel is further emphasized by its general use in heavy stone quarries, iron mines and shale pits, where the character of the work calls for the strongest equipment obtainable.

Osgood "18" Shovel

The many important and well-known advantages characteristic of the Osgood steam shovels have been further supplemented by continuous tread mountings. They are interchangeable with the traction wheels, are set back far enough to avoid being struck by the dipper, and furnish a means of propulsion possessing adequate power and endurance to take the shovel over the softest or the roughest ground. This machine has a very high lift and, by the substitution of a long structural boom for the steam shovel boom, can be quickly converted for clamshell or crane work.

Osgood Ditchers

The actual saving in track maintenance effected through the proper cutting and maintenance of ditches will usually compensate for the expenditure necessary in the purchase of adequate ditching equipment. It has frequently been demonstrated that a ditcher will often do the work of 50 men. The Osgood Company specializes in the design of ditching machines for maintenance-of-way work. To supply the need for a ditcher of large capacity the Osgood "29" has been designed by the Osgood Company. This machine will handle any class of material, blasting being necessary only in solid rock. It is self-propelling and capable of traveling from five to eight miles an hour under its own power.



Osgood "29" Ditcher Working Between Two Dump Cars.

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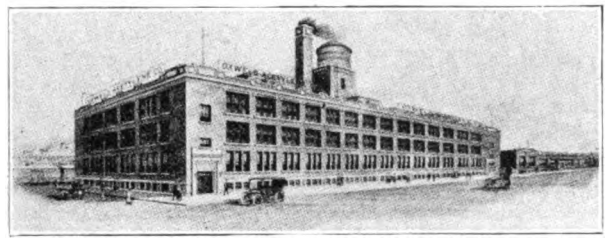
General

No subject has received greater attention from the railroads in recent years than that of the reclamation of materials, and nowhere have the savings been more pronounced than in the repair of track members by means of the oxy-acetylene torch. It has been demonstrated that worn and broken frogs and crossings, switch points and rail ends, can be built up and welded both in and out of the track, to furnish from 75 per cent to

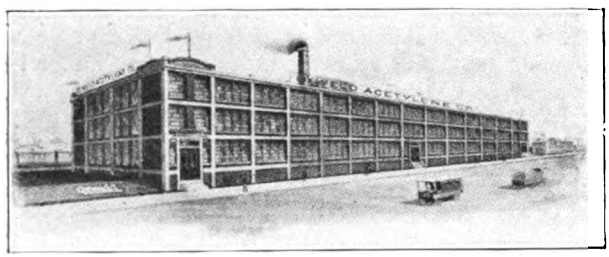


Office and Factory at Chicago

100 per cent additional wear; that rails can be cut or drilled with the cutting torch in practically as neat a manner as with the chisel or drill; and that a vast quantity of the smaller items of track materials can be restored to service, effecting a large aggregate saving in maintenance expense.

The Oxweld Railroad Service Company, as its name implies, was organized solely to furnish service to the railroads in their use of Oxweld apparatus in reclamation, and in building new or dismantled old structures. As the processes of oxy-acetylene welding are comparatively new, and indeed are even now in progress to a still higher development, a large part of this service is in the way of advice, instruction, supervision and co-ordination of knowledge. The latter is a point in this service which is of particular value, since what is learned in one locality is immediately made common information everywhere.

The company maintains an experimental station at Niagara Falls, N. Y., where new combinations of the gases, different qualities of welding rods and suggested improvements in methods are tried out. The station is now perfecting a steel rod to be used in the repair of hard center frogs which, it is confidently expected, will afford equally durable service with the original material. Welding with the ordinary steel rod is now done upon manganese steel in

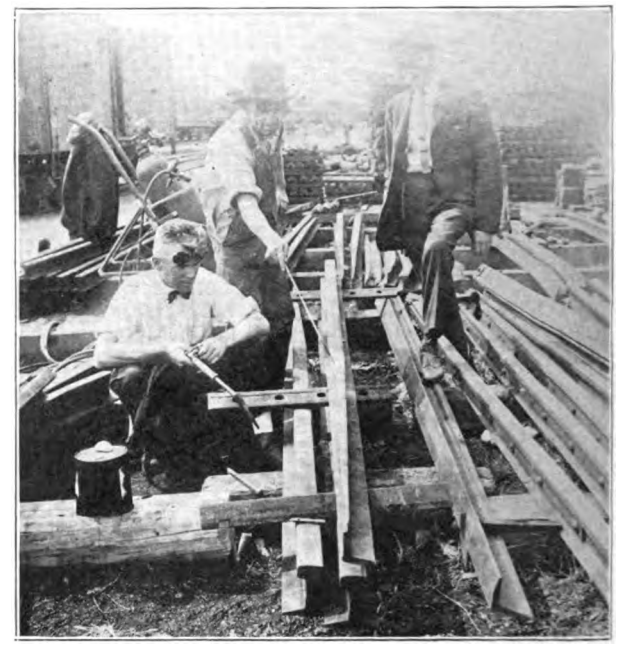


Office and Factory at Newark, N. J.

cases where such repairs are necessary as a temporary expedient.

The men in the Oxweld service organization are drawn directly from the railroads and are thus practical track men who appreciate the importance of attention to the smaller details of maintenance, such as the tightening of bolts, adequate tamping beneath the members, proper drainage, etc. These men look over places where repaired material is installed and advise the local railroad representatives of any unfavorable conditions discovered. From their intimate contact with the work under a wide variety of conditions, they are enabled to gather many new ideas developed locally and to bring them into use on other railways where they are of equal value.

The main office of the Oxweld Railroad Service Company is at Chicago. The service organization has a corps of men distributed all over the country who are prepared to serve every railroad, the smaller one equally with the larger one, with the single object in view of securing the maximum service from Oxweld equipment. If a railroad has a service contract the apparatus is supplied and kept in repair without charge, the only expense then being for the gas consumed. The data and information now available are given to all users, so that the preheating, the admixture of the gases, and the kinds of material employed may all be based definitely upon the charts furnished.



Maintenance-of-Way Reclaiming Yard

The Oxweld Process

The Oxweld process of welding and cutting metals by means of the oxy-acetylene flame is now a well-recognized medium for the economical and quick performance of many operations in maintenance which were formerly well-nigh impossible. The processes are simple and can be performed by an average workman after proper instruction, which the Oxweld Railroad Service Company is prepared to provide. It is one of the salient objects of this service to aid in the development of capable operators, since the efficiency of the process depends largely upon the skill with which it is performed.

In welding with this process two inexpensive gases, acetylene and oxygen, are combined in a suitably-

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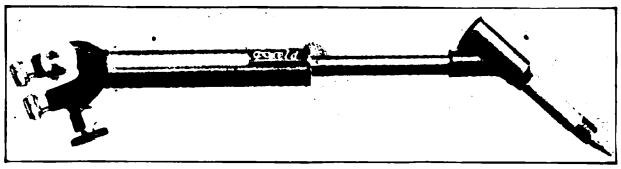
designed blow pipe to produce a small flame developing a degree of heat far greater than that produced by any other gaseous or solid fuel. This high temperature flame (6300 deg. F.) is easily controlled, and



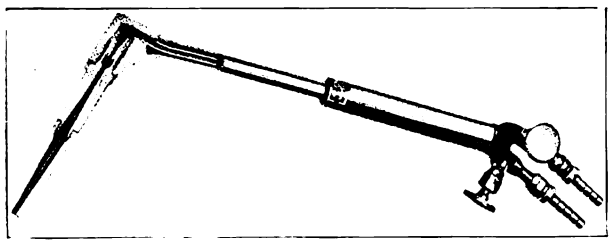
Oxweld Welding Blowpipe

may be applied locally in as small or large volume as may be required. The effect of this extreme heat is to bring the edges of the two pieces of metal to the molten state so that they are fused into one homogeneous piece. Filling material, of the same kind as that being worked upon, may be added to the weld when necessary to fill in or build up the section. Iron and steel plates and castings, aluminum, brass, copper, lead and zinc may thus have their edges joined with a true fusion weld of the same quality and texture as the original material.

The Oxweld process of cutting wrought iron and steel plates and castings, and structural steel work, is based upon the fact that after a spot of wrought iron or steel has been preheated by a jet of mixed acetylene and oxygen, a jet of oxygen directed upon it causes the spot to ignite and be blown away in the form of iron oxide, which results in a narrow clean slot being cut through the section. The action proceeds too rapidly for the heat to spread, and the metal on the side of the cut is neither melted nor injured in any way. Metals up to 14 in. in thickness may be cut rapidly and smoothly along any given plane, the kerf being not over ⅛ in. to ¼ in. wide.

Oxweld Equipment

Oxweld equipment embraces all the appurtenances necessary to perform every welding and cutting operation within the range of the oxy-acetylene process. This equipment is designed to employ the two gases, oxygen and acetylene, efficiently, and to this end is manufactured of a high grade of materials and with careful workmanship. The complete Oxweld outfits are manufactured in the company's own factories by skilled operatives, using specially designed machinery and working under the direction of trained engineers. The Oxweld cutting and welding blow pipes are made

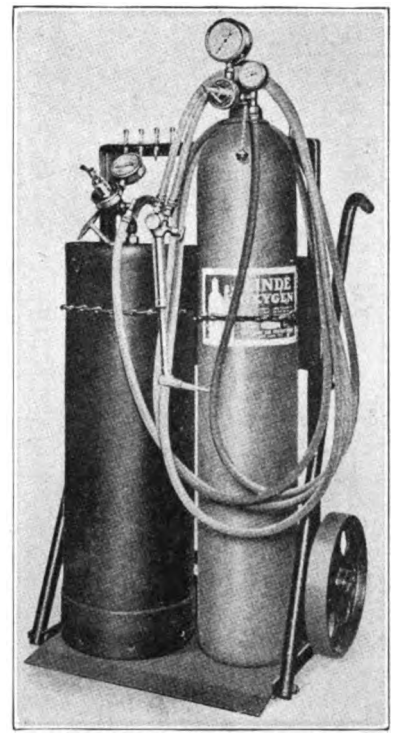


Cross Section Showing Injector Construction

to operate on either high or low pressure acetylene, thus permitting their use with a low pressure generator for stationary work, and with a portable generator or an acetylene cylinder where the portable or emergency equipment may be desirable.

A complete low pressure cutting and welding plant includes a low pressure generator, for making acetylene gas from the chemical action of carbide dissolved in water, an Oxweld welding blow-pipe with five heads and an Oxweld cutting blowpipe with four nozzles. Welding and cutting regulators, each provided with two gages, with the necessary high pressure hose and accessories, are included with the equipment.

For service where portability is a prime requisite, the Oxweld welding and cutting units provide in compact and efficient form a substitute for the stationary generator plant. With this equipment the same blowpipes are used as with the generator plants, and the same character of work is done, the units being specially useful in emergency repair work and for cutting in places which are hard to reach. The equipment is arranged for use with the usual trade oxygen and acetylene cylinders.



Oxweld Welding Unit

The Oxweld blowpipe operates on the injector principle, which causes a very perfect mixture of oxygen and acetylene, resulting in very high flame efficiency. Oxygen passes through the injector at high velocity and draws with it into the mixing chamber the exact quantity of acetylene required for perfect combustion. By employing the injector principle, the Oxweld blowpipe approaches very closely to the theoretical ratio of one volume of acetylene to one volume of oxygen and almost entirely eliminates any variation from a constant neutral flame which might ensue were the admixture of these two gases dependent upon the pressure of acetylene.

The handle of the Oxweld welding blowpipe is made in 5 lengths, 14 in., 17 in., 23 in., 28 in., and 40 in. For the first, Nos. 2 to 6 welding heads are recommended; for the second and third, Nos. 7, 8, 10, 12 and 15; and for the last two, Nos. 10, 12 and 15 on extra heavy work. The welding heads below No. 6 are seldom used in maintenance. The welding handles ordinarily have the heads set at an angle of 45 deg., although angles of 67½ deg. or 90 deg. may be supplied. Each head contains an injector of the proper proportions to produce the correct mixture of gases. The tips are of hard drawn copper and are furnished as an integral part of the head.

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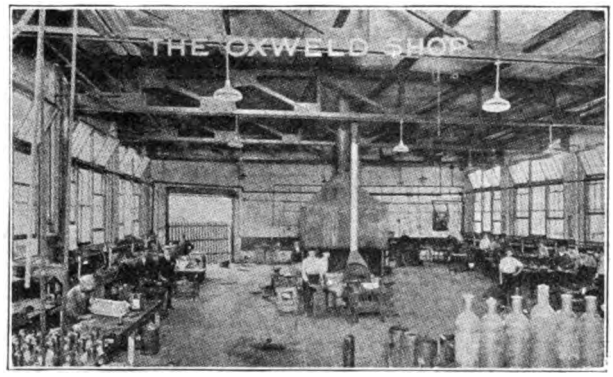
Oxweld Instruction Shops

While it has been found more practicable, in the case of steam railroads, to obtain instruction for their employees under the supervision of Oxweld instructors assigned to visit the points where oxy-acetylene operations are carried on, the company provides an opportunity for employees of industrial or traction companies to learn the process through attendance at the welding schools conducted in the company's large welding shops at Newark, N. J., and Chicago, Ill. At these places students are received and given a course of training under the tuition of men expert in the particular fields, thereby fitting them to carry on this work after the completion of the course.



Oxweld Job Welding Shop

Organization for Oxweld Repair Work

In the United States more than 200 railroads have adopted the service which the Oxweld Railroad Service Company renders in connection with the handling of the welding and cutting process. This service plan furnishes the railroad every possible assistance for insuring the successful and economical use of the process.

While the practice as regards its use by the Maintenance of Way Department varies widely on different roads, the trend is toward a localized use of the equipment directly under the maintenance officer, and most frequently in charge of the roadmaster or supervisor. On some roads the development of the process has been taken actively in hand by the engineer maintenance of way or the general superintendent personally.

A few roads have cars fitted out as oxy-acetylene shops which are moved from place to place, completing accumulated repairs as they go. This shop not infrequently makes repairs to frog and switch material in the track. In the case of crossing frogs, requiring often certain detailed repairs which cannot be done without removal from the track, the emergency set is put in and the old crossings fully repaired on the ground, being then held as the emergency set. On several roads this car has living accommodations for an operator.

One important road has placed the outfits in the charge of the stores department, but varies from this rule for situations embracing large yards or points where material may be shipped into a common shop readily. The latter arrangement usually supplies a somewhat more uniform organization and avoids the overhead expense inseparable from direct control by the store department. The scope of a single unit depends upon the amount of work to be done, but in general an operator does individual work inside and is accompanied by an assistant on all outside work, where flagging or other assistance may be essential.

Applications of Oxweld Methods to Maintenance

The repair of frogs, crossings and switches is the largest single item of work done with the oxy-acetylene torch in maintenance reclamation. Frogs which otherwise would be scrapped are built up on the point and throat, or when required at the toe and heel, to give further service in the track, which often nearly equals that of a new member. Besides the essential building up process, loose rivets are replaced, plates straightened, new bolts put in and the frogs thus made serviceable in all respects. When a wing rail is too badly worn for economical repair a new wing is substituted, either taken from another frog or, if necessary, made new of relayer rail. Not infrequently a fixed wing is substituted for the removable wing of a spring rail frog. When a wing has been broken close to the end, the rail is cut off square, leaving the adjustment for unequal lengths of wings to be made when the frog is applied in the track. The service organization has demonstrated to the roads that repairs should be made before the frog is too badly worn. The expense of average complete repairs to a frog amounts to about $35 for labor, gas, handling and overhead.

Frog Repaired in Track with Oxweld Equipment

In the repair of switch points, the worn member is first clamped to a stock rail of average relayer material and then built up to fit this section. The observations of the service men have shown the desirability of tapping the material with a hammer as it is being welded on, and this has now become the common practice, having demonstrated a greatly increased wear of the points under traffic. This

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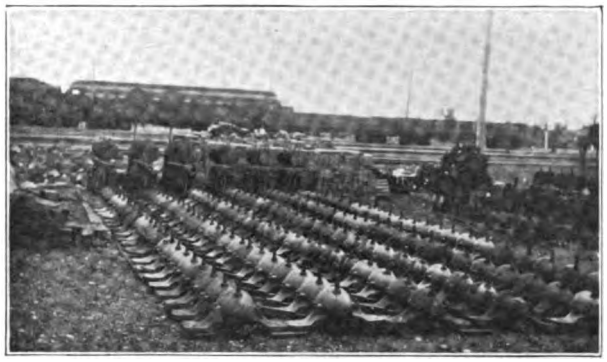
feature also applies to the repair of frogs and crossings, but it is specially important in the case of switches, which are subjected in a greater degree to abrasion from passing wheels and from the hammer blow of the traffic. The supplementary repairs to switches consists in reheating and straightening bent points, tightening rivets, repairing the clips, restoring the foot guards, etc. When the location or the



Switch Stands Repaired with the Torch

design of a switch lug does not adapt the point to use with present types of switch rods the necessary adjustments are made. It is the practice of one road, which makes use of unequal length switch points in yards, to cut back the points which are too badly worn for profitable building up and finish them to the contour of a shortened point for such a combination. The average cost of complete repairs to a switch point is $8.

Crossing frogs are reclaimed both in and out of the track. Where necessary new parts are made out of relayer rails and used to replace the worn out parts. In some cases the base plates are welded to the frogs instead of remaining attached by means of rivets. Guard rails are made by shearing the base with the torch, heating and bending to the required form. A wedge-shaped piece is cut from the web of the rail and, after heating, the ball is bent down upon the base, providing a protection against the guard rail being caught by dragging parts of cars.

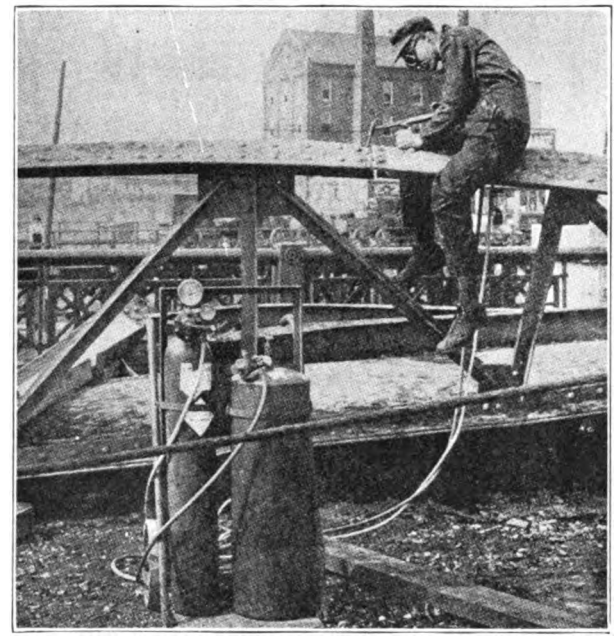
The reclamation of worn and flattened ends of rails in track, especially those laid in city streets where the expense for renewal is extraordinarily heavy, is another item wherein oxy-acetylene welding has proved economical. At stations where much slipping occurs, or on double track where the receiving ends of rails become hammered down, or at insulated joints where the maintenance of a smooth surface saves destruction of the fibre insulation, the process has also been employed to good advantage. By means of the templates and guides now available the drilling and cutting of rails have been made as neat an operation as cutting with a chisel or boring with a drill. The boring may be done without removing the splices. In adapting certain patented types of rail joints to switch work or to use when ties cannot be spaced, the torch provides a method of adjustment which is both quick and neat.

Supplementary Uses of the Torch

There is a practically limitless field for the use of the oxy-acetylene torch in reclaiming the smaller items of maintenance materials, whose value is small in the single unit but large in the aggregate. Among these may be mentioned switch rods, which can be lengthened for greater clearance of switch stands or have worn holes filled out to save lost motion; ground throw stands, which are built up where broken or worn to furnish further service; switch housings, which are often broken by careless spiking and may be restored to their original shape at a considerable saving of expense for new material; and the breakable cranks in switch stands.

The use of the torch has extended to the repair of tools, and claw bars are reclaimed, which work can seldom be done satisfactorily in the blacksmith shop; heads of hammers are built up to full section instead of being further reduced by cutting off the face of the tools; wrenches broken in the jaw are built up to regular shape; shovels which have been cracked in service are welded and returned to use. In numberless other items distinct economy has been shown in the repair of tools at these subdivision shops, and in many of the detailed operations of such repairs the use of the torch is a necessity.

Signal repairmen have found the Oxweld Process useful in welding the broken parts of pipe line connections, detector bar clips, pulley wheels, etc. In water service, boilers, tanks and pipes are repaired, special fittings are made on the job, and tubes are welded in. In the bridge and building department



Cutting up a Bridge Member with Oxweld Unit

steel structures are dismantled, bridges cut apart, and old rivets cut off; while in placing structural steel the torch is of use in cutting, splicing and fitting and a variety of incidental work. The repair of metal bumping posts is likewise facilitated by the use of the torch.

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TACKLE BLOCKS

General

Situations arise with more or less frequency in railway service wherein hoisting equipment is taxed severely and where any warping, sticking, or breaking of hooks or tackle blocks under strain may result in much damage, and possibly in loss of life. It is distinctly to the advantage of railroads under such conditions to possess equipment in whose strength full reliance can be placed under critical conditions.

The W. W. Patterson Company, Pittsburgh, Pa., is a manufacturer of tackle blocks and tackle block parts, clamps, hooks, purchase chain, etc., for heavy service such as is encountered in bridge erection, oil well operation, etc. In this occupation, together with that of general blacksmithing, the company has been engaged over 60 years, the business having been founded in 1858. At the present time the company conducts its business with greatly improved facilities of production but has not seen fit to alter to any appreciable degree the methods of manufacture upon which its reputation has been built. The Patterson blocks are still made throughout by hand from carefully selected materials and by workmen who have been with the company for years. They are regularly used on heavy contracting and industrial work.

Block No. 1

Block No. 2

Block No. 3

Block No. 8

Block No. 23

Tackle Blocks

The Patterson line of tackle blocks comprise two grades, that for extra heavy service, and that for double extra heavy service, the blocks being made in patterns for rope or wire line. All rope blocks have shells of wood, double cross riveted, and, in the case of the snatch blocks, reinforced with an outside strap and with or without an inside strap reinforcing the sheave pin. The extra heavy service rope blocks are fitted with hooks made of stay bolt iron, and flattened, the double heavy service rope blocks, with shackles. Blocks Nos. 1, 2, 3, are three styles of extra heavy purchase blocks. Each style can be made single, double or triple with 3, 3½ of 4¼-in. sheaves for ⅝, ¾, ⅞ and 1-in. rope, respectively. Sheaves for Nos. 1 and 2 are roller or phosphor bronze bushed, those for No. 3 bronze bushed or self oiling. Double extra heavy service rope blocks of the pattern similar to No. 3 except for the hook are made single, double or triple with 6, 7½, 8½, 10¼, 11, 12, 13½ or 15-in. self-oiling, phosphor bronze, or metalline bushed sheaves, for 1¼, 1½, 1⅝, 1¾, 2, 2¼, 2½ and 2¾-in. rope respectively. No. 8 is an extra heavy rope snatch block. These blocks carry 4¼, 5, 5½, 6½, 7⅜, 8, 9 or 10-in. self-oiling phosphor bronze, or metalline bushed sheaves for ¾, 1, 1¼, 1½, 1¾, 2, 2½ and 3-in. rope, respectively, and have both the outside and inside reinforcing straps.

Block No. 23 is an extra heavy wire line block. These blocks have shells of steel, swivel hooks of stay-bolt iron, and flattened, and phosphor bronze or metalline bushed sheaves, and are made single, double or triple with 10, 12, 14, 16, 18 or 20-in. sheaves for ½, ⅝, ⅝ or ¾, ⅝ or ¾, ¾ or ⅞, and ¾ or ⅞-in. line, respectively. Wire line snatch blocks are made in sizes having 6, 8, 10, 12, 14, 16, 18 or 20-in. sheaves for 5/16, ⅜, ½, ⅝, ⅝ or ¾, ⅝ or ¾, ¾ or ⅞, and ¾ or ⅞-in. line, respectively.

Self-oiling sheaves have an oil well integral with the web in which a needle valve and coil spring operate. Prosphor bronze and metalline bushings are lubricated by graphite carried in perforations distributed uniformly and thickly over the area.

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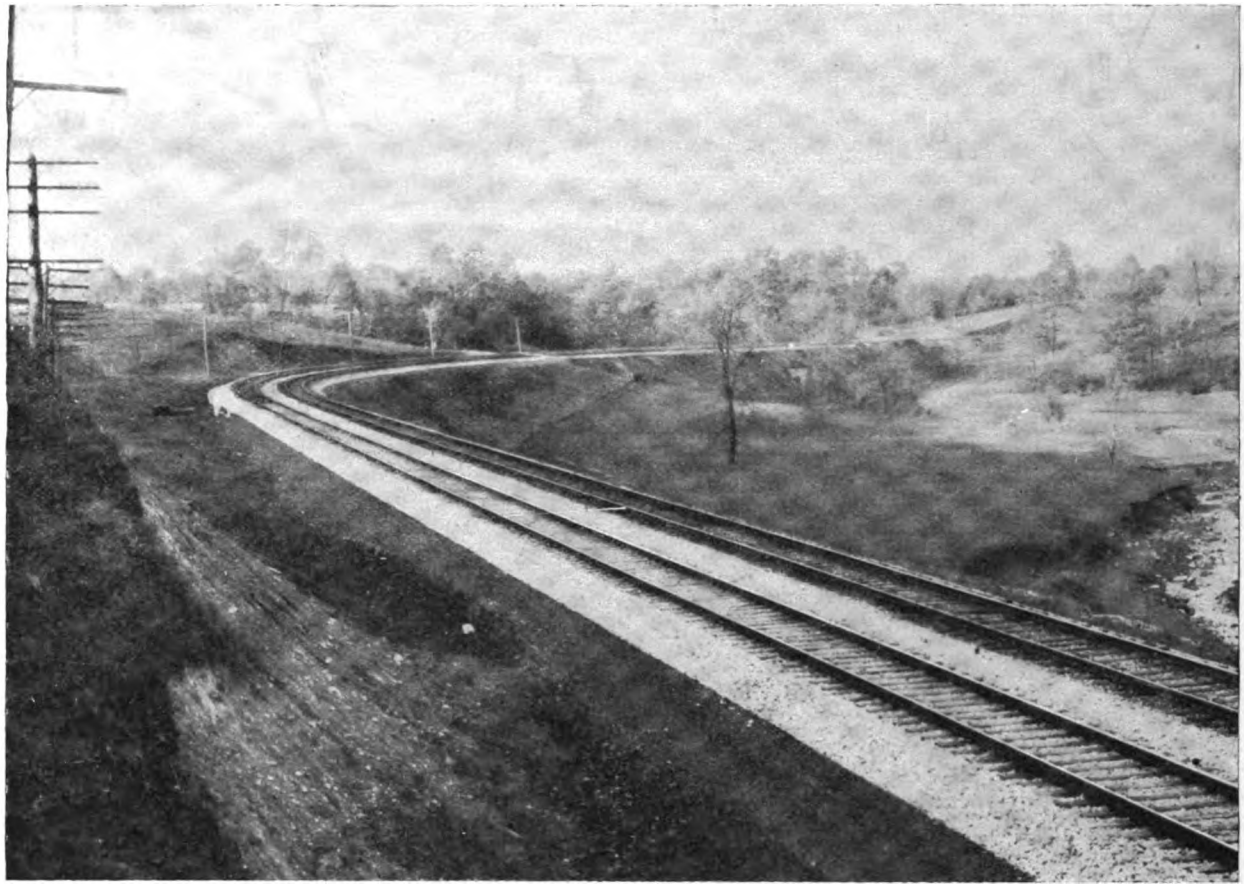
RAIL CREEPING

Causes of Creeping

Rail creeping is defined as the intermittent longitudinal movement of rails in track. The movement is so gradual that ordinarily it cannot be detected except by accurate measurements covering an appreciable period, or by the displacement of rails with reference to other parts of the track or roadbed structure that have not been subjected to the same influences in a like degree.



Rail Creeping on Grade and Curve Controlled by Rail Anti-Creepers.

The principal cause of rail creeping is the wave motion of the rail due to its alternate depression and release under an intermittent load between points of permanent support. The load at the point of contact with the rail, that is, under the wheel, depresses the rail at this point and creates a tendency on the part of the rail that is between points of contact of the load—between two wheels—to rise correspondingly. The movements cause the rail to assume an inverse curve in a vertical plane, which the continuous forward movement of the train converts into an undulating or wave motion. As the momentum of the train constantly exerts a forward pressure upon the upward incline of each wave, it has a tendency to carry the entire rail with it in the same direction. The extent to which this tendency becomes an actual movement depends upon the permanency of the connections by which the rail and the track structure are united with the solid earth upon which they are carried. These connections comprise the fastenings between rail and tie, between adjacent rails, the character of the ballast between and under the ties and the character of the bed upon which the ballast is supported. The stability of the track and hence its resistance to the tendency to creep are also dependent upon the quality of the ties, their spacing, the drainage of the roadbed, etc.

There is also a cause of rail creeping which frequently makes trouble in yards or near stations or interlocking plants, where brakes are frequently applied. When a moving body is in contact with another that is normally stationary, there is a tendency on the part of the moving body to transmit a part of its movement to the second or stationary body, the degree of the tendency depending upon the amount of friction generated between the two. The application of the principle to railway track arises in the fact that when the brakes upon a train are set, the momentum of the train carries it some distance, thereby converting what was before rolling friction into sliding friction. The latter form of friction establishes a much more energetic connection between the moving body—the train—and the normally stationary body—the track—and therefore greatly increases the tendency of the train to carry the track with it.

Another instance of increased friction between the wheel and the rail which may have a tendency to cause creeping sometimes results from curvature, particularly in the case of trains moving over a curve at a slower speed than that for which it has been elevated. In this case the inside wheels receive a

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preponderance of the load, inducing a greater degree of friction between them and the rail which may cause creeping of this rail. The reverse of this condition may arise when the speed of the train over the curve is greater than that for which the outer rail is superelevated. In this case the tangential momentum of the train creates a tendency of the outer wheels to climb the rail, inducing an abnormal friction between the wheel flange and the head of the rail. The tendency here is for the outer rail to creep.

It follows from what has been said that creeping of rails is most likely to occur at places where brakes are customarily applied, as at approaches to stations, bridges and curves, on yard tracks, at approaches to interlocking stations, etc., and on descending grades and on tracks laid in marshy places or where for other reasons the roadbed structure is lacking in stability. The general tendency of creeping is in the direction of traffic on double-track roads and in the direction of the heavier traffic on single track. There are however, exceptions, due, perhaps, to the preponderance of other or local causes over the more general causes which have been cited. There are also on record instances of rail creeping of which definite causes appear to have defied analysis.

Effects of Creeping

When rails begin to creep among the first visible indications are the opening up of joints at the point where creeping begins and the closing of expansion openings in the direction toward which creeping takes place. The latter may result eventually in the kinking or buckling of rails under high summer temperatures. Other indications are dragging or slewing of ties, which may exist to the extent of tightening the gage of the track; loosening of spikes; pushing switch points and crossing frogs out of line; intensifying curvature, etc. All of these effects lead to increased cost of maintenance, in driving rails back, straightening the position of ties, etc., and because uncontrolled creeping may lead to dangerous conditions, its prevention or reduction to a minimum constitutes an important and ever-present problem of track maintenance to the solution of which every available remedy should be freely applied.

Preventing Rail Creeping

Numerous mechanical appliances have been developed for the prevention of rail creeping. Some have failed because of mechanical unfitness, others because of cost or difficulty of application, and many because they could not endure the rough usage to which they were subjected.

The P & M Co. has devoted many years of study and experiment in the endeavor to perfect appliances that will arrest rail creeping or reduce it to a minimum, which would at the same time be of low first cost, of permanent durability, and of simplicity of application by unskilled labor. The company now manufactures four rail anti-creepers, which afford a wide latitude to individual preferences in selection, and demonstrate by the extent of their use the completeness with which they serve the purposes for which designed.

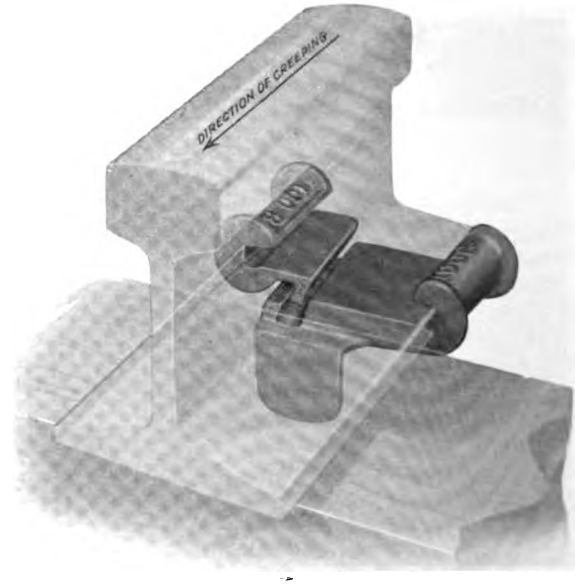
Means for Preventing Rail Creeping

The principle on which all of these four anti-creepers operate is as follows: Each device has a positive grip upon the base of the rail thus bringing the resistance to rail creeping down to its point of contact with the cross-tie. A part of each device comes in contact with the side of the cross-tie. When the rail starts to creep the grip of these devices becomes stronger and the devices are pressed against the ties. If the rail creeps it must push the cross-ties along. The ballast holds the cross-ties in place. With usual track maintenance, any one of these four devices will reduce forward track creepage. The results gained are the holding in place of the vital points of track, such as points of curve, switch points, frogs approaches to bridges, crossings, crossovers, turnouts and interlocking devices. They also serve to hold track in position against a great number of minor displacements which cause so large a part of maintenance expense, among which may be mentioned particularly tracks over draw-bridges and on turntables, where the movement of the rails is liable to cause fouling of these rails with those adjoining on the structure or on the ground, and entail serious delays.

The four forms of anti-creepers manufactured by The P & M Co. are known as the P & M, the Vaughan, the Henggi and the Ajax. The cost price of installing either of these rail anti-creepers is small when compared with the results obtained in safety and cost of maintenance of track.

The P & M Anti-Creeper

The P & M boltless anti-creeper is made in two parts, both of which are of malleable iron, a material of great strength and non-corrosive. It is installed by slipping a part on each side of the rail and driving the parts together for about one-half to two-thirds of their length. The bearing face should fit snugly against the side of the cross-tie opposite the direction of creepage. The wedge form of the contact faces causes the movement of the rail to tighten the two



P & M Anti-Creeper

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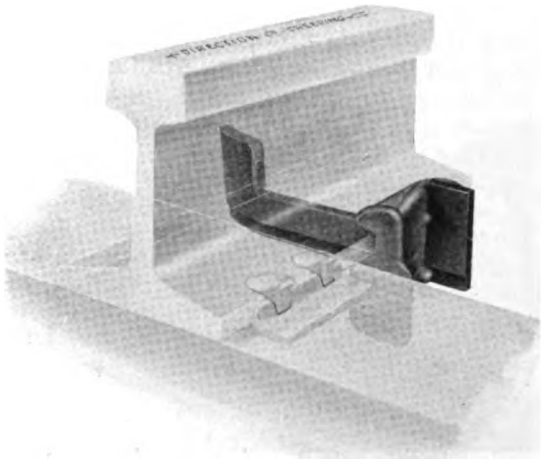
parts in a firmer hold. Its application requires neither the drilling of rails nor the use of special tools.

The Vaughan Anti-Creeper

The Vaughan is an automatic rail anti-creeper made in two parts—a malleable iron shoe and a tempered oil-treated steel yoke. Its initial hold upon the rail is obtained by the spring



Vaughan Anti-Creeper

of the yoke, but when the hook end of the yoke is driven forward, placing the yoke in a diagonal position across the rail, it has a permanent set so that the pressure against the shoe as it resists creeping will automatically tighten the grip of the anti-creeper on the rail. It is installed or may be removed with wrenches which are furnished free of charge with every shipment, and it can also be applied or taken off with an ordinary monkey wrench. High speed train vibration will not loosen this anti-creeper nor will the backing up of the rail when ballast is frozen around the bearing face interfere with its effectiveness.

The Henggi Anti-Creeper

The Henggi is a tempered steel, one-piece anti-creeper in the form of a double hook, of which the connecting part is bent upwardly to bear against the base of the rail when the

Henggi Anti-Creeper

hooks are forced over the opposite flanges. It is held upon the rail base entirely by its resiliency and when in operative position rests against the side of the tie.

The special advantages of the Henggi anti-creeper are that it is in one piece; there is no part that can come loose and fall off; it can be applied easily and quickly with a maul and no other tools, and by unskilled labor; it is not affected by reverse creeping or backing up of the rail; can be fitted to any rail section, even though the rail may have lost by corrosion, and can be reapplied many times.

The Ajax Anti-Creeper

The Ajax anti-creeper is somewhat similar to the P & M in that it consists of two pieces that retain their hold upon each other and upon the rail flanges by two series of wedging faces acting horizontally and vertically, which are opposed to the direction in which the rail has a tendency to creep. The bearing against the tie is similar to that in the P & M, and as in that form the creeping force tends to cause the two parts of

Ajax Anti-Creeper

the anti-creeper to grip each other and the flanges of the rail more closely. The material is malleable iron.

All of these anti-creepers have been designed with a view to ease of application by unskilled labor and with the tools ordinarily forming a part of track gang equipment.

These devices are handled for Canada by the P & M Co., Limited, Coristine Building, Montreal, Que., and in Europe by The P & M Co. (England), Limited, 31, Budge Row, London. These companies maintain service organizations of experts in rail anti-creepers who may be called upon at any time for advice in the solution of difficult rail creeping problems. They afford valuable assistance to railway maintenance service by traveling over track on their own account to ascertain whether these anti-creepers are being used in the most effective manner, often pointing out sources of possible trouble before the trouble has opportunity to occur. By their constant study of the many angles of the subject and in a more practial way by their readiness to instruct the actual users of these devices, the observance of practices which extended experience has indicated to be most effective is assured.

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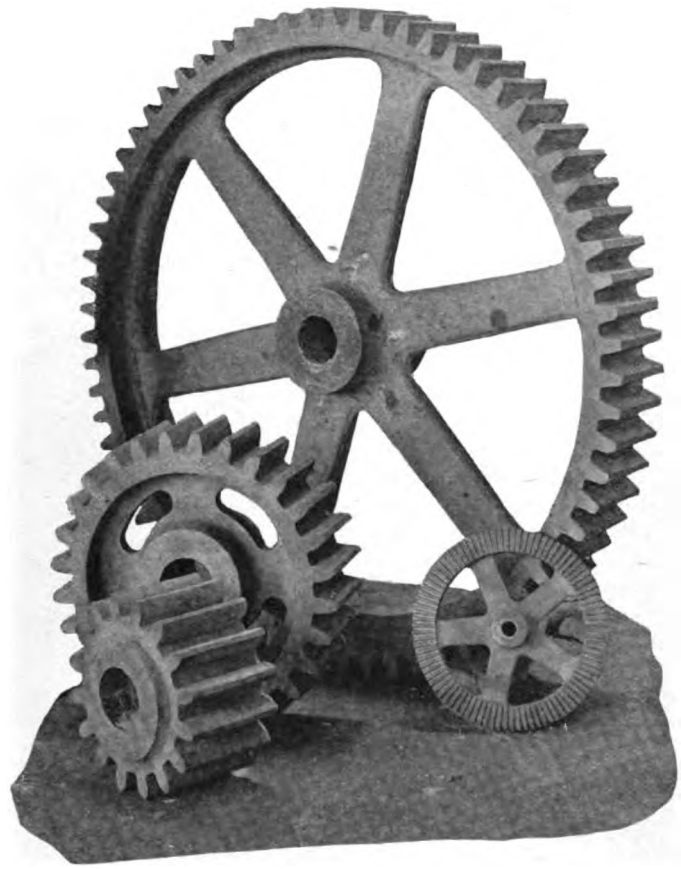
General

The use of steel castings on the railroads is an extensive one, not only in locomotive and car construction and repair, but in maintenance as well, for boiler and pipe fittings, particularly in high pressure work; for cast steel gears and pinions, used in locomotive coaling plants and other similar structures; for the panel points of wooden Howe truss bridges and for special purposes in bridge maintenance, such as for raising the structure or renewing broken end bearings; for the bases and caps of columns, as well as for the columns themselves; for the centers of and the locking pockets appurtenant to turntables; for a large proportion of the housings of signal mechanisms and for various items of repair in signal maintenance; and especially, in the case of manganese steel castings, for the wearing parts of ballast crushing machinery, for steam shovel dipper parts and for the inserts of frogs, switches and crossings.

The Pelton Steel Company, Milwaukee, Wis., with both open hearth and electric furnaces, together with a completely equipped heat treating department, is prepared to fill orders for plain carbon, alloy or manganese steel castings, to meet chemical analyses or physical requirements. By reason of its long experience in the steel foundry business and by virtue of its staff of expert engineers and foundrymen, the company is able to furnish dependable and durable castings at a moderate cost.



Cast Steel Gears and Pinions Made at Pelton Steel Company's Plant

Pelton Facilities

The open hearth furnaces with which the Pelton Steel Company's plant is equipped, produce plain low carbon steel castings wherein the phosphorus and sulphur contents are controlled through the use of a high grade of steel scrap as well as a proper kind of pig iron. The provision of electric furnaces permits the use of the most oxidizable alloying elements, such as Vanadium and Chromium. It is also possible in these furnaces to obtain any desired carbon content in the steel castings, and to control the other elements commonly found in all steels. The removal of the occluded gases is obtained in the customary manner by the use of manganese and silicon in the furnace and the super-deoxidizers in the ladle.

The Pelton Steel Company's furnaces are also equipped to produce manganese steel castings of a high grade, containing any specified percentages of manganese, and heat treated by the most up-to-date and approved process. Every design of casting is made which it is possible to cast from manganese steel. In the class of maintenance castings are included such items as jaw plates, check plates, toggle bearings and all wearing parts in ballast crushers; teeth and other wearing parts in steam shovels, dipper dredges and ditching machines; crane wheels and sprocket wheels; track shoes, derailers and rail clamps; and the hardened inserts of track work

Pelton Service

It is in the adaptation of his metal to special requirements that the manufacturer's experience is most vital. Steel castings for particular uses often require a special degree of strength or other characteristics to meet the requirements of the part, members, machine or device. The necessary strength or characteristic is usually specified by the engineer or designer of the device or machine. Frequently the kind of steel is specified by designating the chemical analysis and the physical characteristics. In case the latter alone is specified, the foundryman is supposed to meet the physical strength or characteristics by delivering a steel of such a chemical analysis as will attain the required specification.

The Pelton Steel Company is equipped to fill orders for steel castings either upon chemical analyses or physical requirements. Practically any reasonable specification can be obtained by the use of one or more alloying elements in the steel. The years of experience of the company in the production of steel castings enables it to produce a quality of material calculated to afford durable service.

The test bar selected for the symbol of the Pelton Steel Company indicates its special function in meeting physical tests in the castings produced by its furnaces. This symbol is stamped on all castings manufactured by the company and is an assurance of reliability as well as durability.

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Organization

Pettibone Mulliken Company, Chicago, began business in December, 1880, under the firm name of Pettibone & Mulliken, and at the present time has a capital of $10,000,000. The corporation manufactures frogs, switches and crossings, in carbon rail and manganese steel, guard rails, switch stands, taper rails and rail braces. The various designs now produced are the result of 40 years of study and practical experience, but A. R. E. A. designs are furnished when so specified. The corporation has its own steel foundry, where it produces both open hearth and manganese steel, the electric furnace being used exclusively in this production.

Frogs

The corporation manufactures clamp frogs, bolted frogs, spring rail frogs, solid manganese frogs and manganese insert rail bound frogs. The clamp frog which it manufactures is known as the Strom clamp frog and has been in use on prominent western railroads for over 30 years, being the standard rigid frog on many of these roads. The life of a rigid frog depends on the wear of the rails, and that wear increases whenever the fastening which holds the frog together becomes weakened or impaired. The great advantage of the Strom clamp frog is in the vertical clamp which does not weaken nor break, but holds the parts of the frog together solidly, enabling any wear to be taken up at a minimum of expense. Any form of bolted frogs requires constant attention in maintenance to keep the parts together, necessitating tightening of bolts and replacing of those that break. Furthermore, the first cost of a standard bolted frog is much greater than the first cost of a standard clamp frog, so that the Strom clamp frog is economical in first cost, economical in maintenance and consequently a safe frog to use.

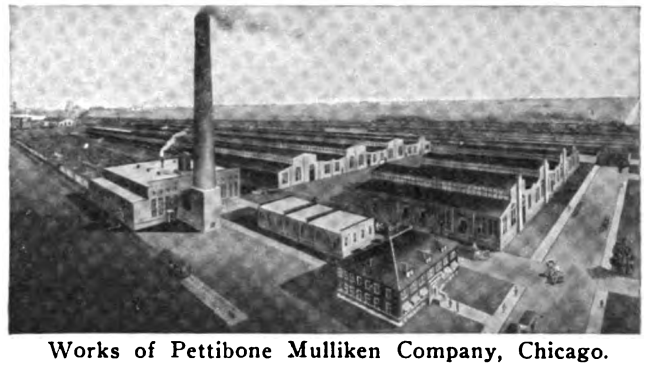
Spring rail frogs of various designs are generally used in main tracks. Some roads have installed rail bound manganese rigid frogs in the main line at all sidings, but these rigid frogs have not given general satisfaction, due to the fact that the open throat of the frog must be crossed by every wheel, the jar at this point increasing as the wear at the throat increases, which makes a decided interruption in the smooth riding of the track, whereas the passage of the wheels on a spring rail frog is scarcely noticeable. Furthermore, the cost of the manganese frog is from 50 to 75 per cent greater than that of the standard carbon spring rail frog.

Guard Rails

For many years, while the standard length for rails was 30 ft., guard rails were made 15 ft. long, and were bolted to the stock rail. Over ten years ago Pettibone Mulliken Company began to investigate the proper length for guard rails and their maintenance, and found that a shorter guard rail would answer every purpose. The 7-ft. 6-in. and 8-ft. 3-in. guard rails, which can be cut without waste from 30-ft. and 33-ft. rails respectively, furnish a sufficient protection to the frog point, require less expense in fastenings for holding them in position, and save one-half in rail. When it is taken into consideration that there are thousands of guard rails in use throughout the United States, a saving of one-half the rail becomes an enormous economy. With the introduction of the shorter guard rail, Pettibone Mulliken Company introduced the same vertical clamp for holding the guard rail to the main rail that is used in the Strom clamp frog; and this type of clamp has given entire satisfaction and become generally used.

Switches and Crossings

When Pettibone Mulliken Company first began the manufacture of track equipment, stub switches, as they were then called, were used extensively. Finally the split switch was introduced, and its use at present is practically universal. While split switches are made in any length, as with the guard rail, it is economical to cut the points from standard length rails without waste, so that 11-ft. split switches for yards and 16-ft. 6 in. split switches for main line are now recommended as standard lengths.



Works of Pettibone Mulliken Company, Chicago.

In connection with the use of split switches it was found that there was more or less wear at the point, and it was desirable that there should be some form of adjustment by which this wear could be taken up. Pettibone Mulliken Company devised what is known as the Transit Clip, which permits each point to be adjusted independently, so that all wear can be taken up readily, the device being effective, easily adjusted and perfectly safe. The patents on this device having expired, it has come into general use and has displaced many other forms of adjustment.

Pettibone Mulliken Company manufactures carbon rail crossings of all angles and designs, and manganese steel crossings of the latest designs, including the Balkwill patent articulated crossing and the Pettibone Mulliken Company design No. 177, which is an articulated crossing with individual points of merit. As the company has its own steel foundry and pattern shop, it is in position to make prompt deliveries of manganese work.

Switch Stands

The switch stands manufactured by Pettibone Mulliken Company have been known for a generation. They are the Banner stand, the Star stand, the Box stand, the No. 1 Hub stand, the No. 2 Hub stand and the Hub safety stand, as well as many forms of ground throw stands. The particular features of all these switch stands are their simplicity of design, strength of material and construction, and a minimum of weight, reducing first cost, the cost of transportation and the cost of installation.

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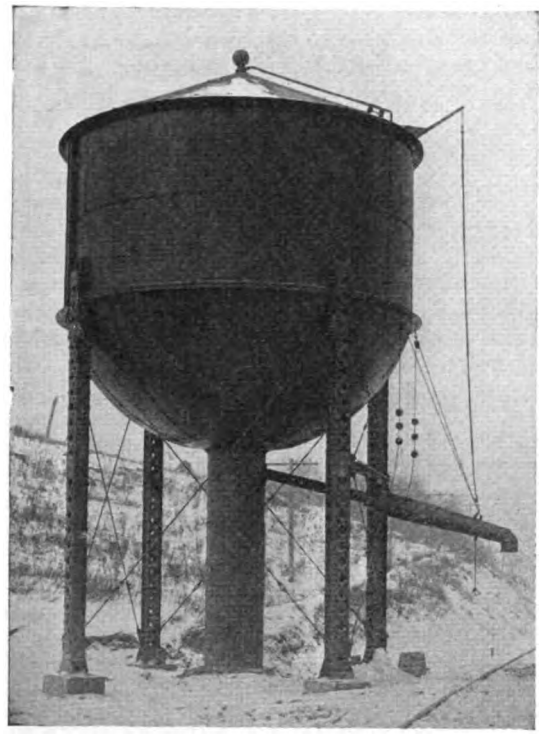
General

The Pittsburgh-Des Moines Steel Company, Pittsburgh, Pa., is a builder of elevated steel tanks, standpipes, bridges, coaling stations, smoke stacks, steel buildings and other structural work. In the United States these products are manufactured in two fabricating shops, one at Pittsburgh, Pa., and the other at Des Moines, Iowa. An associated company, the Canadian Des Moines Steel Company, Ltd., is located at Chatham, Ontario. Sales offices are located at Pittsburgh, Pa.; New York City; Dallas, Tex.; San Francisco, Cal.; Chicago; Washington, D. C.; Des Moines, Iowa; and Chatham, Ont.



P. D. M. Standard Type Railway Tank

The Pittsburgh-Des Moines Steel Company is a concern of over 25 years' experience and its plants are of large capacity. As illustrating the extent of its output, during the war it furnished the government alone with 12,000 tons of ship plates, eight wireless towers of 800 ft. and over in height (the LaFayette station, at Bordeaux, France), and many large water tanks. All sizes of structural work can be fabricated in its shops, where facilities are provided to insure reasonable promptness in the filling of orders, a large stock of material being kept on hand at all times. While the larger part of its business originates in the United States and Canada, its products are also used extensively in Australia, Africa, South America, and the islands of the Pacific.

The company is a contractor as well as a manufacturer and is organized to design and erect as well as fabricate work. The ability of the company with its specialized experience thus to take over structural work of any kind and carry it to completion can often be utilized to a buyer's advantage. The engineering department is in a position to co-operate with prospective customers in determining their requirements, without charge or obligation on their part.

P. D. M. Railway Tanks

The elevated steel tanks built by the Pittsburgh-Des Moines Steel Company are used extensively by railroads in the United States and other countries for locomotive and terminal water service, fire protection, etc. They form a type of equipment which has met with favor by the railroads owing to their adaptability to many railroad problems. Although introduced in this field less than 25 years ago, elevated steel tanks are now in use on practically all the leading roads to such an extent that the amount of steel being used in their construction prior to the war was so great that the government placed restrictions upon production, all of which restrictions have since been removed.

The water tank is an indispensable part of the physical equipment of a railway, and because of the bearing which it has upon the operation of a road as well as the expense involved in the erection and maintenance of the large number employed, close attention is being given to their selection. The expansion which has taken place in the traffic of the railroads has required a corresponding development in water tank construction, while the increase in the size of terminals and in the size and number of locomotives, etc., has created a demand for greater storage and more efficient supply. Many tanks having capacities of 100,000 gals. accordingly have been installed to replace those of 50,000 gals. or less. Coincident with an increase in size of many tanks there has arisen a tendency to increase their height to afford greater pressure, and to install them away from the tracks to afford a clear view or to supply more than a single point with water. Also more importance is being attached to the need of more adequate fire protection, owing to the increased value of property, etc., and to the need of more dependable service under all conditions.

The tanks built by the Pittsburgh-Des Moines Steel Company have been designed to meet these needs for larger, more efficient, and permanent construction. They are in use by private and public concerns of all kinds. They are built in sizes ranging from 10,000 to 1,000,000 gals. capacity and can be erected at any location.

For railway service the Pittsburgh-Des Moines Steel Company builds two special types of tanks—the P. D. M. Standard and the Cold-Climate. These conform to standard design and embody the essential features required in modern tanks for railway service as determined by extensive study and experimentation by engineers and tank manufacturers. Where conditions require special treatment, the company is prepared to modify these standards or to make special designs to meet the requirements adequately.

P. D. M. Standard Type

The Pittsburgh-Des Moines Standard types of tank are of designs approved by railway engineers and found by experience to be satisfactory and economical for the average installation. They can be built for any capacity and elevation practical in railway service and for loco-

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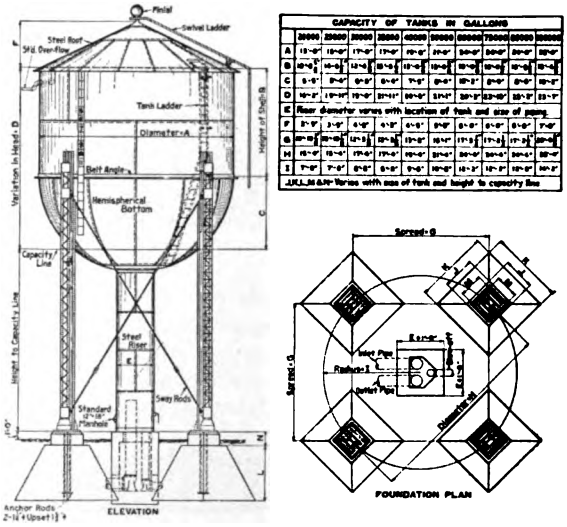
motive standpipe or roadside service. Their adaptability is further promoted by a number of special features. They are built entirely of steel and are of pleasing appearance. The tank cylinder is of small height in comparison to its diameter, thus obviating the trouble often arising from a large variation in



General Plan P. D. M. Standard Railway Tanks

head. The bottom is hemispherical, a feature which is advantageous from a structural standpoint and affords the greatest capacity in the tank for a given amount of metal. This type of bottom, by draining toward the center, also affords self-cleaning facilities, a feature which is often of particular advantage where muddy water is encountered, eliminating the expense and delay involved in taking a tank out of service and removing the mud by hand, and also avoiding trouble arising from the accumulation of excessive sediment on the tank bottom. Another feature of the standard type is the riser pipe which decreases the column loading, serves as the inlet and outlet pipe and often eliminates the need of frost boxing. The large diameter of the pipe affords adequate protection from freezing under average conditions and co-operates with the tank bottom in affording self-cleaning facilities, the sediment forced into it by the slope of the tank bottom being removed whenever desired through a suitable mud valve operated from the outside. The riser accommodates the inlet and outlet pipes which extend far enough upward to avoid the mud in the riser bottom, and is equipped with a manhole for permitting entry for making repairs. The inlet, outlet and mud valves are easily accessible from a roomy pit below the riser pipe. The Standard type is also distinctive in its ladders, each tank being equipped with a column ladder, a ladder which revolves around the tank, and an inside ladder. These give convenient access to all parts of the tank for inspection or painting.

Cold-Climate Type

The Cold-Climate railway tank is designed for installations where extreme weather conditions are encountered, and has amply demonstrated its ability to meet adequately the requirements of such service. It embodies the features desired in a modern railway tank for average use and in addition is designed to give unfailing service during the coldest weather experienced in the United States and Canada. In this type a heating compartment is substituted for the steel riser pipe of the Standard type, the walls of the compartment being double with an air space between for preventing radiation, and consisting either of hollow tile or of a steel frame supporting steel mesh plastered inside and outside. This chamber accommodates a stove, the heat from which passes through the body of the tank to the space below the roof by means of two pipes connected to the tank bottom. A third pipe, the smoke flue, also passes through the body of the tank and through the roof, the section above the roof carrying a sliding ball altitude indicator which is prevented from freezing by the escaping heat. All pipes and valves, including those of the clean-out system, are grouped near the heat pipes, entering the tank in that section of the hemispherical bottom which forms the ceiling of the heating chamber. On the inside these tanks are equipped, when desired, with a wooden ceiling, and are provided in the bottoms with wood fenders to prevent ice from interfering with the operation of the valves. The outlet valves are operated from below by a connecting rod, lever arm, and chains accessible from the locomotive. In this type of tank the inside tank ladder is flexible to avoid trouble from floating ice.

Other Products

The Pittsburgh-Des Moines Company is also a large designer and fabricator of standpipes (steel tanks without towers), steel pressure tanks, structural building of all kinds, coaling stations, and other standard structures. A complete stock of structural shapes, plates, bars, angles, and reinforcing rods is carried in the shop for immediate shipment.

The railway coaling stations built by the company are built entirely of steel and consist each of a large steel tank carried above the track on steel frame work, an elevator shaft for raising the coal from the pit below the tracks to a height where it can be dumped in the tank, and of suitable chutes and hoppers for feeding coal into the tank or delivering it to locomotives. The storage tank has a funnel-shaped bottom for guiding the coal into the hoppers and the elevator buckets are designed to fill and empty automatically. This type of coaling station is fire-proof, and offers but little obstruction to view.

Coaling Station

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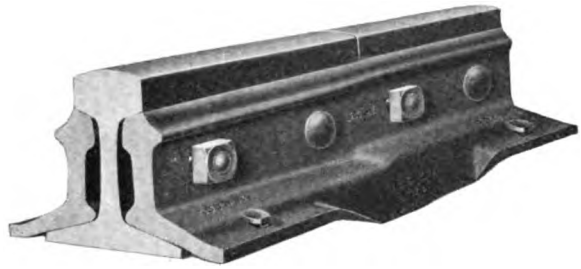
Bonzano-Thompson Rail Joints

The Bonzano-Thompson rail joints in connection with which the phrase "the joint as strong as the rail" had its origin, embody the efforts of the Q & C Company to eliminate low joints and battered rail ends, and to insure

Bonzano-Thompson Plain Rail Joints

a smooth riding track. In these joints the construction of the webs or gussets, an exclusive feature of the Bonzano-Thompson equipment, is such as to make each joint a uniform and continuous girder. The joints are also distinctive in the distribution



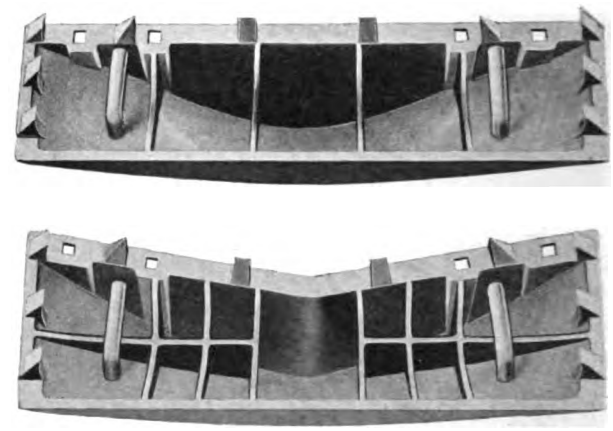
Bonzano-Thompson Compromise Joints

made of the metal by which great strength is insured without undue weight. The section of the blubhead is unusually large and it presents no interference to worn wheel flanges. Bonzano-Thompson joints have a uniform sectional area throughout their length and accommodate all track bolts.

Q & C Car Replacers

The Q & C Company manufactures two types of replacers, the Fewings and the Newton. The claims made for the Fewings type are that they cannot cut ties on any bearing surface; that they are of such a design as to make tipping impossible, and that the derailed wheel can mount the rail from any point of replacer. Where spiking is inconvenient, clamps can be furnished to provide the means of holding the replacer to the rails.

The Newton divided replacer is designed for use at switch points where there is no room to use replacers of the regular type. Each replacer is divided lengthwise into two halves, each half comprising a replacer which can be used between switch points and stock rails in narrow places, and both halves bolted together, comprise a replacer of the regular type. The shape of each half is also such that when used at switches it protects the switch point from being bent.



Fewings Type Wheel Replacer

Q & C Electric Snow Melter

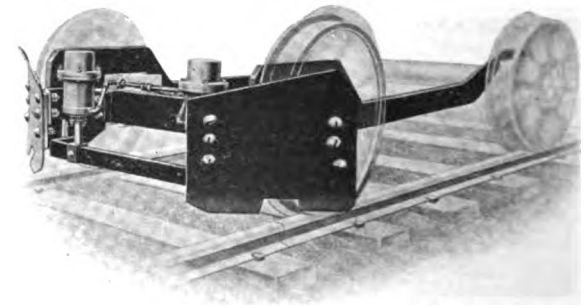
A problem which the maintenance of way department is concerned is that of keeping switches and interlocking connections in operative condition during the winter months when they are liable to become clogged or put out of service by the accumulation of snow and ice.

Q & C Electric Snow Melter

Both safety of operation and continuity of traffic require the certainty of free working of these parts. The Q & C Electric Snow Melter is simply an electric heater inclosed in a water tight cast iron box. These heaters consume 700 watts and have a heating capacity of 350° Fahrenheit. The average single turnout switch requires 14 to 18 units. They are designed to operate on either 110 volts A. C. or D. C. current.

Ray Snow Flanger

While it is generally recognized that rotary or wedge plows are a necessity in deep snow, the locomotive snow flanger is also a necessary part of the maintenance equipment, not only in the removal of snow of less depth than



Q & C Ray Flanger

that requiring a plow, but in clearing rails and flange-

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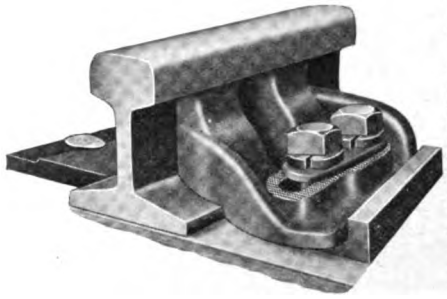
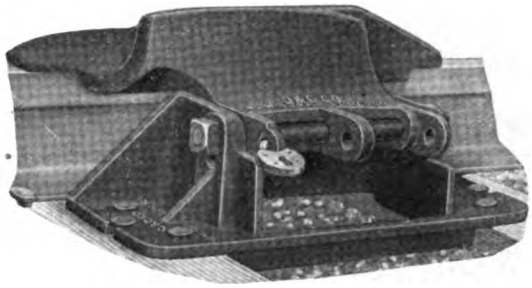
ways after the plow has passed in order that there will be no delay in traffic. The general construction of the Q & C Ray Flanger is shown in the accompanying illustration. The operation is controlled by compressed air. The flanger is adapted for use on all kinds of rolling stock.



Q & C Adjustable Rail Brace

Q & C Adjustable Rail Brace

The Q & C Adjustable Rail Brace is valuable at switch points where wear is to be taken up. The adjustable feature is important as it saves the expense of taking worn rails out for readjustment.



Q & C Portable Derail

Derails

The Q & C Company manufactures a derail for every requirement. This collection includes the portable, hand operated and mechanical types. They are made left or right hand, or for double throw. The derails are adjustable and suitable for all rail sections.

The company also manufactures switch and target stands.

Rail Benders

Rail benders have a various use in maintenance at the present time and their relatively large importance on many roads has been further increased by the practice adopted by leading roads in accordance with higher standards of maintenance of accurately bending rails for laying on curves. The principal features of the Samson Rail Bender are its capability of performing

Samson Rail Bender

the bending operation rapidly and of allowing quick release. It can be carried and operated by one man and is capable of bending rails up to 100 lbs. section in or out of the track. These benders are carried by many roads also as a part of the wrecking equipment.

Skid Shoes

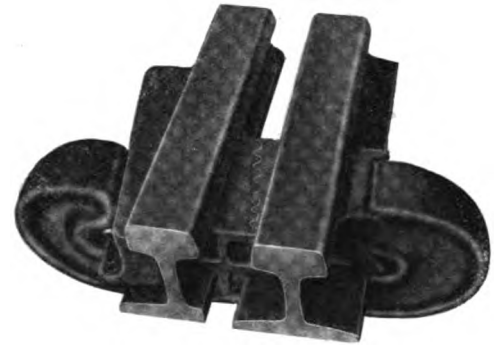
Q & C Skid Shoes were designed to avoid the delay to traffic occasioned by waiting upon the wrecker in situations where breakdowns occur as a result of broken or loose wheels, damaged axles, or defective trucks. In the event of such occurrences, the skid shoes are placed on the rails in front of the crippled truck. The truck is then rolled upon them and thereupon becomes locked automatically against any forward movement. The damaged truck in this position can be skidded out of the way, the Q & C Skid Shoes allowing this operation to be performed wherever a

Q & C Skid Shoes

wheel will roll, including switch points, frogs, and curves.

Q & C Universal Guard Rail Clamp

The Q & C Universal Guard Rail Clamps are made in two sizes, Nos. 3 and 4. The clamp as illustrated provides an adequately strong and safe means of securing the guard rail under heavy traffic. They can be applied easily



Universal Guard Rail Clamp

and quickly without removing the guard rail. The yoke of each clamp is of high carbon, open hearth steel, drop forged and of the "I" beam construction. The wedge, adjustable filler blocks, and shoe, are made of high grade malleable iron, accurately fitted to the section of rail. As the yokes are interchangeable for all standard "T" sections of rail, it is only necessary to order new malleable fittings when changing rail sections.

Q & C Portable Rail Saw

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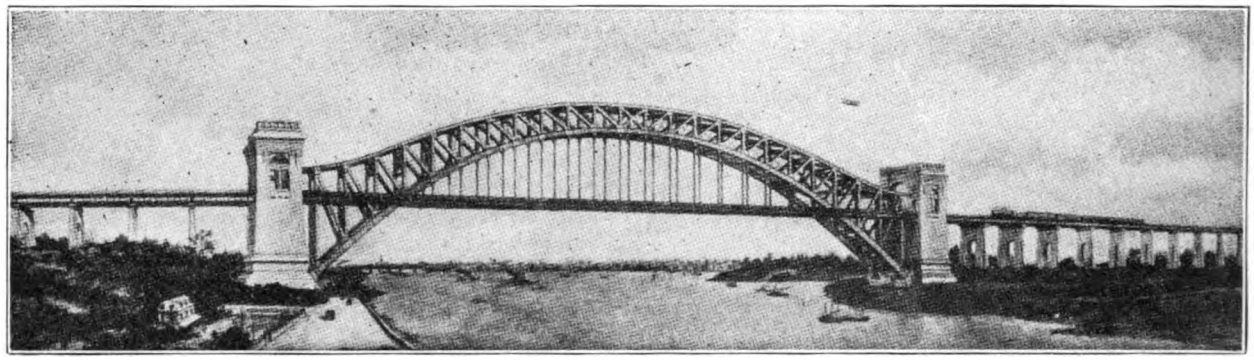
CREOSOTE WOOD PRESERVATIVE

General

The Protexol Corporation, New York City, is the manufacturer of a line of coal tar products which includes wood preservatives, weed killers, disinfectants for stock cars and pens, and shingle oils. These products are extensively used by railroads. In the manufacture of the wood preservatives, the company devotes its attention chiefly to the production of three special preparations intended particularly for brush, spray, and open tank applications, but it can also furnish all standard commercial grades of creosote including oils prepared specially to conform to railway specifications. It maintains a department having a resident representative in England on the importation of bulk creosote oil for pressure plants. The company's special wood preservatives are Protexol, Anolineum (a standard grade of anthracene oil), and Neosote (a refined and redistilled creosote oil). Of these, Protexol is the highest grade product.



Hell Gate Bridge, New York City, The 3,000,000 Ft. B. M. of Timber in Which Were Open Tank Treated with Protexol

Protexol

This product of the Protexol Company is the wood preservative sold for some 40 years by the Carbolineum Wood Preserving Co. under the name of Avenarius Carbolineum, the changes in the organization and name of the product being consequences of the war, Avenarius Carbolineum being a product of foreign manufacture and control while Protexol, of identical composition, is exclusively American.

Although not technically a creosote, the product is one of the class of wood preservatives so classified by railroads, it bearing a resemblance to creosote and being basically a product of coal tar. As such it belongs to the group of preparations which constitute, to quote the American Railway Engineering Association, "the best timber preserving agent known for all purposes," creosote embodying, as practically all railroads at the present time recognize, a combination of desirable characteristics, chief among which are its wide range of use, its capability of being applied in the field by brush, spray or dipping, as well as by pressure processes in a plant, the color indication given of its penetration, its antiseptic qualities on fungi that cause wet and dry rot of wood, the protection it affords against the boring of wood destroying worms, the resistance it affords against the leaching action of water, and the protection its lubricating nature is capable of affording to timber against surface checking, splitting, and mechanical wear.

Protexol, itself, is composed of the chlorinated liquid oils derived from anthracene, the nearly solid constituent of coal tar, distilling between the creosotes and the final product, pitch. The comparative value of anthracene as a preservative is evident in the light of A. R. E. A. and government reports to the effect that the coal tar oils having the higher boiling points are the better preservatives and stating specifically that oils "containing a high percentage of anthracene oil, will remain indefinitely and protect the wood from decay and boring animals."

As placed on the market the product constitutes an oil of a very low volatility, and one which will remain liquid at low temperatures, by virtue of which it can be handled without difficulty in the manner for which it is specially intended; that of brush application and open tank treatment. It conforms to the following specifications:

Specific Gravity of 38 deg. C	Min. 1.10, Max. 1.115
Flashing Point	140 deg. C. Min.
Burning Point	170 deg. C. Min.
Distillate to 250 deg. C	2% Max.
Distillate between 250-300 deg. C.	15% Max.
Distillate between 300-350 deg. C.	35% Min. Max.
Character of Residue	Soft at 20 deg. C.
Tar acids per cent of total distillate	10% Max.

Uses

The Panama Canal and the Hell Gate Bridge are two of the more prominent projects for which this preservative has been specified. In 1917, 20 per cent of all treating to standing telegraph and telephone poles was done with it. In railway service, under both its present and former name, it has been widely used in the preserving of trestle work, bridge, stringers and ties, piling, flooring, telegraph and telephone poles, fence posts, etc. As a preservative it not only affords the means of giving newly erected structures an effective initial treatment in the field, but also both of materially prolonging the life of structures like piling, poles and fence which have begun to rot, and of affording a highly satisfactory protection to those parts of pressure treated timber (usually the very parts most susceptible to decay) which are exposed by the framing work done upon it after the pressure treatment. As to the efficacy of treating partly rotted timber, records of service on the butt-treating of poles indicate that brush applications of Protexol made according to the prescribed methods will at least double the ordinary life of poles.

PROTEXOL CORPORATION, NEW YORK CITY

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General

The Railroad Supply Company is a manufacturer of tie plates, and rail braces, which form essential elements of the track structure. It also supplies tie plugs, as well as a variety of tools for track work. The "Chicago" Derailer is one of its important track devices designed for the protection of traffic on the main tracks. The derailer is bolted to the rail and is thereby always in the proper position with reference to the head of the rail.

The Railroad Supply Company is also a pioneer in the development of the highway crossing signal. Its newest device is the Style T Wig Wag. It also supplies different styles of bells for direct current or alternating current circuits, bridge warnings, and crossing signs.

Its signal accessories include annunciators, battery chutes and boxes, relays and relay boxes, resistance units, switch boxes, and track instruments. In connection with track circuits the company supplies various types of insulated joints, bond wires, channel pins, and bonding drills. Wire tape, solder, tags, wire sleeves, battery zincs, and coppers, are among the signal supplies furnished. Its extensive line of electrical equipment includes the various testing instruments required by the inspectors and maintainers.

The Railroad Supply Company has its main office at Chicago; it also maintains a sales office at 30 Church St., New York.

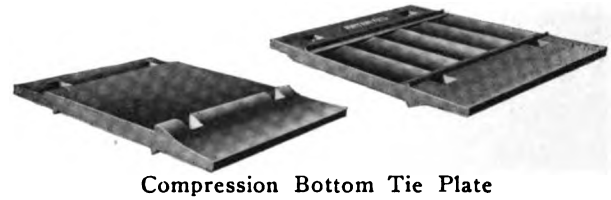
RRS Co. Tie Plates

The Railroad Supply Company manufactures many different designs of tie plates for either cut or screw spikes. Its tie plates are of Bessemer or open hearth steel and are made entirely from new billets. A special alloy steel tie plate is also supplied which has a high resistance to corrosion. The advantages demonstrated for the RRS line of tie plates are due to the use of a material of high tensile strength, made correctly to section and weight.

The design of the tie plates is based on the essential requirements of stiffness, to avoid buckling in service; security of seating, to prevent motion on the ties; a sufficient area properly to transmit the pressures; and distribution of the metal to co-ordinate strength with the minimum of weight. With these provisions the RRS tie plates are equipped to perform the two essential functions of a tie plate, viz.: to save wear of the tie and to maintain proper gage of the track.

The Undulated Bottom Type, No. 30 and the Compression Bottom Type, No. 122, are two Railroad Supply Company specialties, each of them being made with flat or canted flat rail bearing surfaces and in various detailed patterns and sizes. Both types have straight rail sustaining shoulders. In the former, the flanges run lengthwise and the undulations are crosswise, while in the latter the flanges run crosswise and the undulations lengthwise.

Undulated Bottom Tie Plate



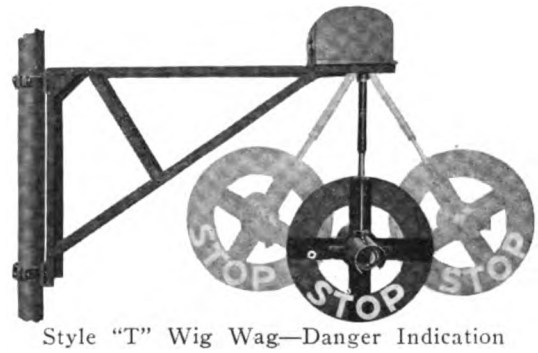
Compression Bottom Tie Plate

The undulated bottom plate is designed to avoid mechanical wear of the tie by holding the plates, through their flanges, against any motion on the tie. The undulations bed into the tie without injury to the fibres. The compression bottom type of plate, by compressing the fibres, makes the wood hard and supplies a firmer seat for the plate.

RRS Highway-Crossing Devices

The Railroad Supply Company was one of the first manufacturers to place a crossing warning bell in service on the railroads, the original type of bell still being standard on many of the largest roads to this day. Its automatic highway protection is thus a result of more than 20 years' experience. Its devices are characterized by a high grade of both material and workmanship, which in turn reults in a minimum of maintenance.

Its Style "T" Wig Wag is a recent development in motor-driven automatic crossing protection. It is made for both two and three position indication and the mechanism operates on direct or alternating current of any commercial voltage up to 600 volts.



Style "T" Wig Wag—Danger Indication

The three position type gives three distinct indications, viz.: clear, by the disc being turned at right angles and presenting its edge to the highway; danger or stop, by the swinging of the banner or disc over the highway; and emergency stop, by the disc dropping by gravity and presenting its face to the traffic whenever the power is withdrawn.

Style H Interlocking Relay

The Railroad Supply Company's Style "H" relay has long been standard on many roads. It is simple in design and rugged in construction, having in particular the feature of protection from dust or unauthorized adjustment. The Style H-75-A relay is enclosed in a glass cover and sealed in accordance with R. S. A. specifications. The relays are furnished without cover if desired.

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General

The Rail Joint Company has its general office at 61 Broadway, New York, and maintains branch offices at Boston, Mass., Chicago, Ill., Denver, Colo., San Francisco, Cal., St. Louis, Mo., Philadelphia, Pa., Troy, N. Y., and Montreal, Can. The company's works have been located at Troy, N. Y., for twenty-three years, which is also one of its shipping points, others being at Buffalo, N. Y., New York City, Steelton, Pittsburgh, and Johnstown, Pa., Joliet, Ill., and Columbus, Ohio, affording convenient points for prompt deliveries.

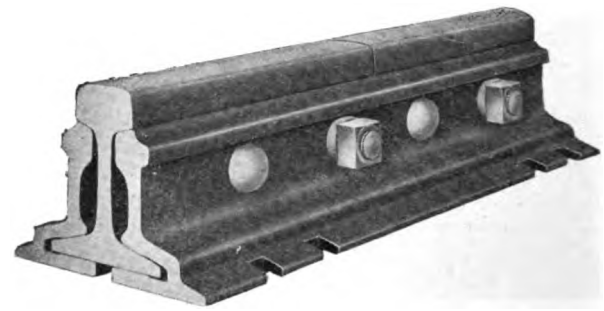
This company is a specialist in the design and manufacture of standard, insulated and compromise joints. It is an especially large maker of base-supporting joints. It is also an extensive manufacturer of other types of joints for standard, high tee, and girder sections; for use with block signals; for frogs and switches; and for step or compromise purposes.

Next to crossties the greatest single item of expense in the upkeep of the railroad is for rails. The life of the rails is determined not alone by flange wear but also, and in many cases primarily, by the battering of the ends. While the practice of sawing rails has reduced somewhat the loss of material through this cause, the immediate and real means of saving the rails is to furnish such support for the ends that the battering will be reduced to the minimum. The impacts from wheel loads will be present at the joints in greater or less degree, no matter how high the standard of maintenance. The problem is to counteract it. There are three principal methods of resisting the effect of this force, viz.: (1) By supporting the base of the rails; (2), by bridging the joint; and (3), by increasing the strength of the angle bars. The Rail Joint Company employs all of these methods, singly or in combination, in its several products, which are the Continuous, 100 Per Cent, and Weber joints.

The Continuous Joint

The Continuous Rail Joint consists of two improved angle bars with the bottom leg of each bent inward to provide a grooved or shallow channel section for the bottom of the splice whereby the rail base is gripped above and below and held securely throughout the entire length of the joint. The bottom of the splice is extended as a toe to reinforce the channel, and also to provide a means of slot-spiking the joints as a check against creeping, when this is desired. The base plate ordinarily performs the functions of a bridge plate and tie plates in supporting the rails, and in any circumstance increases the strength of the joint to the extent of the resistance to tension of the section at the apex of the groove. In an extreme case where the joint occurs entirely between the ties, the feature of a bridge plate is absent. In its general use the lower angle of the channel supplies base support for the rail under wheel loads applied directly over the joint, while the reinforced upper angle resists the reaction when the wheels have passed beyond the supporting ties. The Continuous joint thus serves as nearly as possible to make the rails a continuous girder.

By engaging the rail at the three points of greatest reaction, the bottom of the head and the top and bottom of the base, the maximum of support for the cross section of the splice is obtained. The stresses throughout the rail section also are more nearly equalized, thus reducing rail breakage. The wedging action of the joint, in close contact with the base and head, not only maintains the rails in surface, but assures correct alinement of the ends of adjacent rails. The base of the splice provides a larger bearing upon the tie than is the case with the ordinary tie plate and besides making more efficient use of the cost of the tie plate, affords greater bearing where it is especially needed. As the Continuous joint consists of but two pieces, simplicity of design is conserved.



Continuous Joint

The base-supporting feature supplies the means of reducing to the minimum the hammer blow from the traffic. This type of joint is particularly effective when the respacing of ties at the joints to provide for suspended joint is neglected. Some of the largest railway systems in the United States, which have made it an established practice to omit the respacing of ties when laying new rail where it would be done solely for the purpose of obtaining a suspended joint, have adopted the Continuous type as standard for all new installations. The idea that a main function of the joint is to hold the rails against creeping has been partially abandoned on several roads where the Continuous joints are supplied without provision for slot anchoring the joints.

Maintenance is further reduced through the use of the Continuous joint, by reason of the less labor required for tightening bolts. With the ordinary angle bar a severe strain is set up in the bolts through the horizontal resultant of the downward force acting upon the inclined surface of the top of the splice. In the Continuous joint this force is resisted by the bearing of the bottom plate against the base of the rail. This is supplemented by the perfect fit provided with the head and base of the rail. Tests have shown that the only tension on the bolts of a Continuous joint is that required for holding the unloaded joint firmly to the rail.

The Continuous joint not only resists deformation of the rail ends, but the close-fitting feature of this joint, engaging both sides of the base and one side

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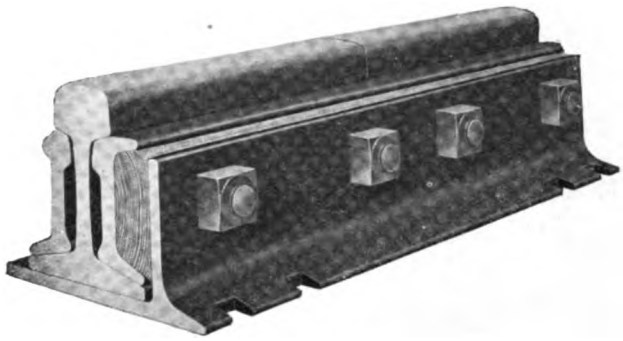
of the head, supplies a practical means of restoring to normal surface rails that are beginning to get surface-bent. As the rail is brought nearer to a straight contour the splices are driven home and the bolts drawn tighter. A few weeks commonly suffice to correct a bad degree of surface bending. A further advantage of this joint arises from the absence of shock, which prolongs the life of the bond in electrified sections and saves wear upon the bond wires in automatic signal territory.

The Weber Rail Joint

The Rail Joint Company manufactures also the Weber Joint which is used in considerable quantities on several important trunk lines where it has given good service under heavy traffic. The essential feature of this joint is base support by means of the horizontal leg, which extends through the entire width of the joint. A single improved angle bar for the inside splice is mated, for the outside splice, with a fish plate of

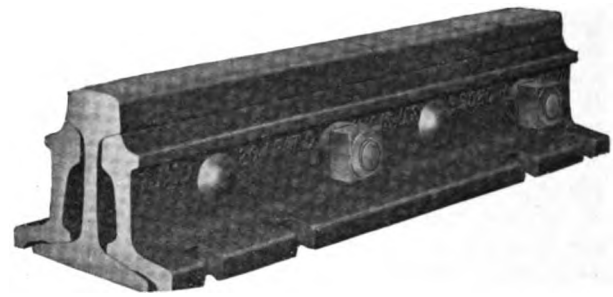


Weber Joint

channel section, which is relatively the strongest section in use. A wood block fills the space between the channel and the vertical leg of the shoe angle and makes all four parts of the joint function as one. The block takes up the vibration from the wheel loads and thus obviates a main cause of loose bolts. This advantage also decreases bond wire failures, which are due principally to unresisted impacts. The wide bottom leg permits the punching of holes for spiking on the inside and slotting on the outside, which provision augments the holding power of this joint against creeping of the rails. The plain base allows the joint to be used where the spacing of ties is omitted, but it is of maximum effectiveness when used as a suspended joint. The Weber Joint is also much used with high tee and girder rails.

The 100 Per Cent Joint

The 100 Per Cent Joint employs the third means of resistance to deflection, that of more efficient distribution of the metal in the cross section than is characteristic of the ordinary angle bar. The special advantage of this type of joint, besides its simplicity in the use of only two parts, is the ability to employ it with equal facility as a suspended or supported joint, or where the



100 Per Cent Joint

respacing of ties is omitted altogether. Special study was necessary to obtain the proper distribution of metal to afford maximum strength for a given amount of metal, and the service obtained with these joints proves that the design is correct.

Compromise Rail Joints

The Continuous Compromise (or step) rail joint has the base-supporting feature and is supplied to connect different standard sections of rail, or tee with girder rails. The section is similar at the heavy section end to that of the ordinary Continuous joint and the step is made

Continuous Compromise Joint

by increasing the thickness of the base plate, as may be necessary to accommodate the compromise desired, and by an offset in the head of the joint. Special attention is given to the use of an exceptionally high grade of annealed cast steel having an elastic

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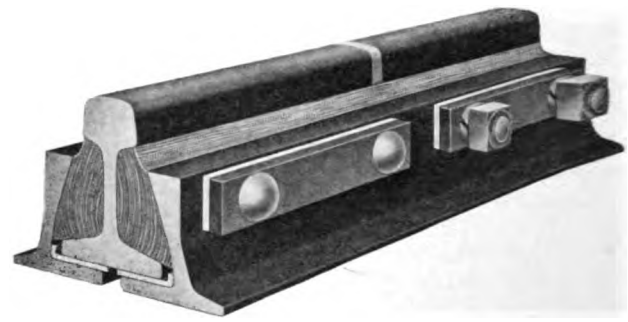
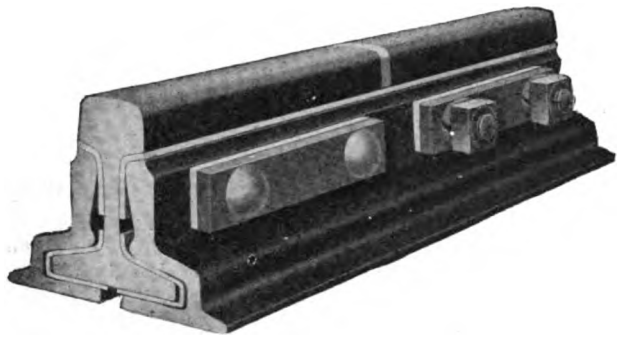
limit of over 40,000 pounds per sq. in. In the case of the high step from standard to girder rail section, a saving in metal is effected by employing an I-section for the tee rail seat. As these joints are almost always used with the suspended type of joint, lugs are provided at the four corners for spiking to the ties.

Insulated Joints

The Insulated Joints made by the Rail Joint Company are of three general designs, the Continuous, Troy, and Weber. Each of these has the base-supporting feature.



Troy Insulated Joint



Continuous Insulated Joint

Continuous Insulated Joint

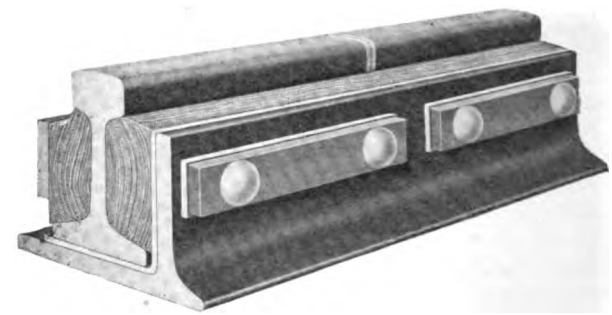
The Continuous Insulated Joint is similar to the non-insulated Continuous Joint with the necessary fibre insulation added and with its section adapted to provide such areas and thicknesses of fibre as have been found necessary to reduce replacements to a minimum under the heaviest trunk line service. Nut locks, and high tensile track bolts with oval necks, are also used to insure the joints against loosening after they have been carefully installed. Positive alinement bearing against the fillets and rail web just under the rail head is also an important factor in the high efficiency of this joint.

Troy Insulated Joint

The Troy Insulated Joint has the same track bolt features as the Continuous Insulated Joint but it is otherwise essentially different in that twin metal shoes are combined with twin blocks which interlock with twin base-fibre plates and are so clamped to the rail as to provide a symmetrical, base supported, wood block type of insulated joint which is specially adapted to localities where the close attention that should be given to any insulated joint in service is impractical. It will stand a lot of abuse and can usually be employed to distinct advantage where such conditions cannot be avoided during part of a year at least.

Weber Insulated Joint

The Weber insulated Joint is also of the wood block type and has the track bolt feature similar to both the Continuous and Troy Insulated Joints. The wood blocks and the fibre and metal shoe parts are not symmetrical and its basic principle of resisting load thrusts directed diagonally outward requires this joint to have two or more tie supports to render its use advantageous. Where such conditions prevail, both signal and track results are excellent.



Weber Insulated Joint

Twin Insulated Joints are also made up in special modifications or combinations of the Troy and Weber Insulated Joints to suit local conditions.

Insulated joints are only satisfactory where adequate maintenance is observed. On some roads this is assured by a requirement that such joints shall be tamped once each week and that the bolts shall be kept tight. It is also important that they shall be properly applied. Their effectiveness as regards insulation is largely dependent upon the quality of fibre insulation used and The Rail Joint Company in its several insulated joints uses exclusively the highest grade of fibre which is obtainable.

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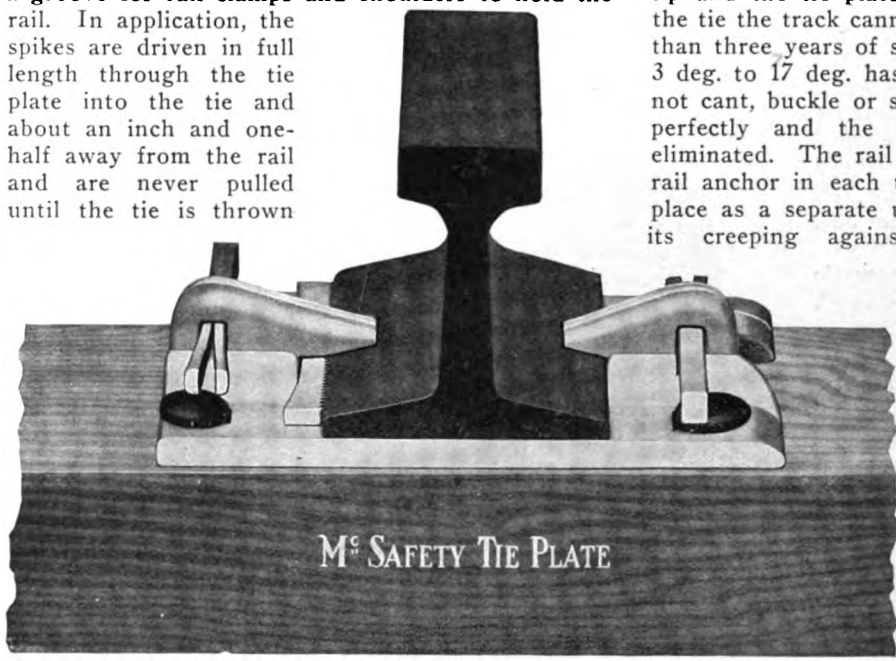
The McVicker Tie Plates

This tie plate prevents the rails from creeping and from tipping, the track from spreading and ties in service from spike killing. "THEY HOLD THE TRACK."

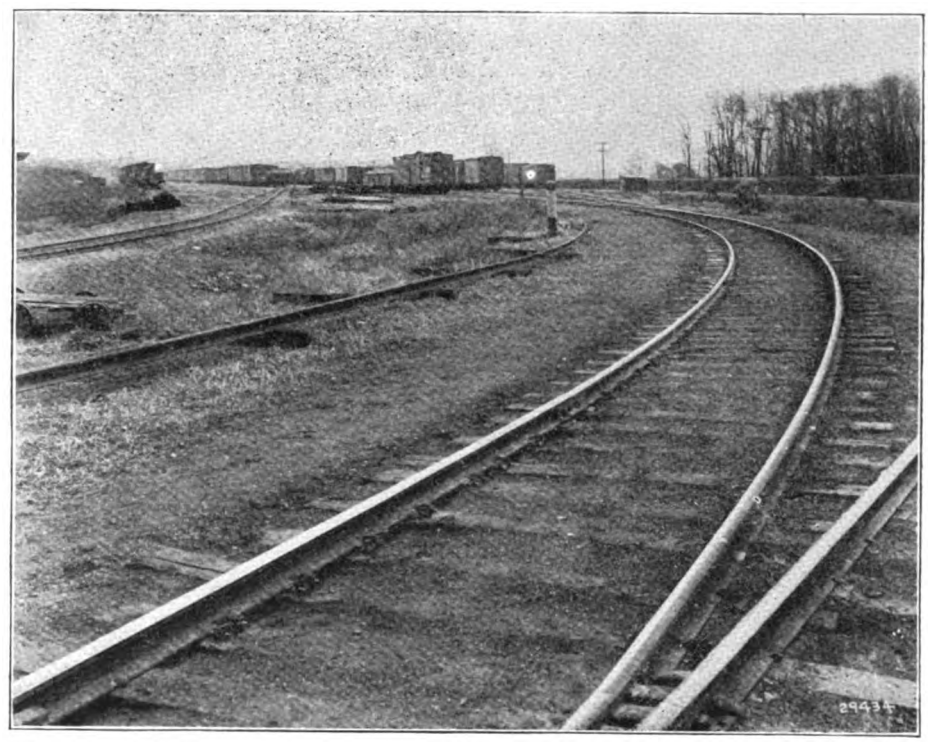
The McVicker Tie Plate is formed with each end split longitudinally and bent up to an incline forming a groove for rail clamps and shoulders to hold the rail. In application, the spikes are driven in full length through the tie plate into the tie and about an inch and one-half away from the rail and are never pulled until the tie is thrown away. Strong, removable rail clamps are slipped into the grooves in the tie plate up against and over the rail and hold the rail firmly to the tie plate and split keys are inserted crossways under and against the rail clamps and over the spike heads and the split ends spread, holding the rail clamp firmly on to the rail and the spikes in the tie plate and tie. The rails are prevented from creeping either way by the firm clasping of the rail clamps and our rail anchor bar, wedge-shaped both ways, fitting between the inside rail flange and the shoulder on the tie plate under the rail clamp. The track is regaged by transposing this rail anchor bar and rail clamp from the inside to the outside of the rail flange, thus shifting the rail in about ½ in. to take up the wear on the inside ball of the rail.

To remove the rail the split keys are driven out and the rail clamps slipped back in the grooves away from the rail and the rail lifted out and another rail dropped into its place, the rail clamps then slipped back into place, the split keys inserted and spread and the track is restored without having pulled the spikes, thus preserving the wood in the tie.



The rail being held firmly to the tie plate cannot strain on the spikes—only a side pressure and more tip and the tie plate being spiked down firmly to the tie the track cannot spread. There is no pulling than three years of service on curves varying from 3 deg. to 17 deg. has proved that the tie plates do not cant, buckle or spread. The track is thus held perfectly and the maintenance expense thereof eliminated. The rail being held to every tie by the rail anchor in each tie plate holds each rail in its place as a separate unit in the track and prevents its creeping against the next rail and the battering of the end of the receiving rail, as well as all the other bad resultant causes of rail creeping which are well known to every railroad official, engineer and roadmaster.

These tie plates are of the greatest importance on all curves on main lines and in all troublesome places because they hold the track in such places. The saving of lives and property is so much more important than the little additional cost of these Safety Tie Plates that every railroad should install them first in all of their curves and troublesome places.



The McVicker Tie Plates are installed here on a 17-deg. curve where engines were off the track almost daily previously and not one has been off since. They are saving a previous annual maintenance expense of $500 and much destruction of property.

RAILWAY SAFETY TIE CO., CHICAGO, ILL.

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AUTOMATIC SAFETY SWITCH STANDS

General

The Ramapo Iron Works have been for many years extensive manufacturers of standard railroad track material, such as switches, switch stands, frogs, crossings, guard rails and guard rail clamps for heavy as well as light equipment, manganese special work in a variety of designs and several other devices of a similar character which they manufacture exclusively. Their large plants at Hillburn, New York, and Niagara Falls, New York, furnish facilities for handling promptly both the actual work of manufacture and delivery of large and diversified orders. Their products have been tested by years of actual service and merit the consideration of the best trackmen of the country.

Automatic Safety Switch Stands

The Automatic Safety Switch Stands, their leading specialty, have a reputation of long standing for durability and long life.

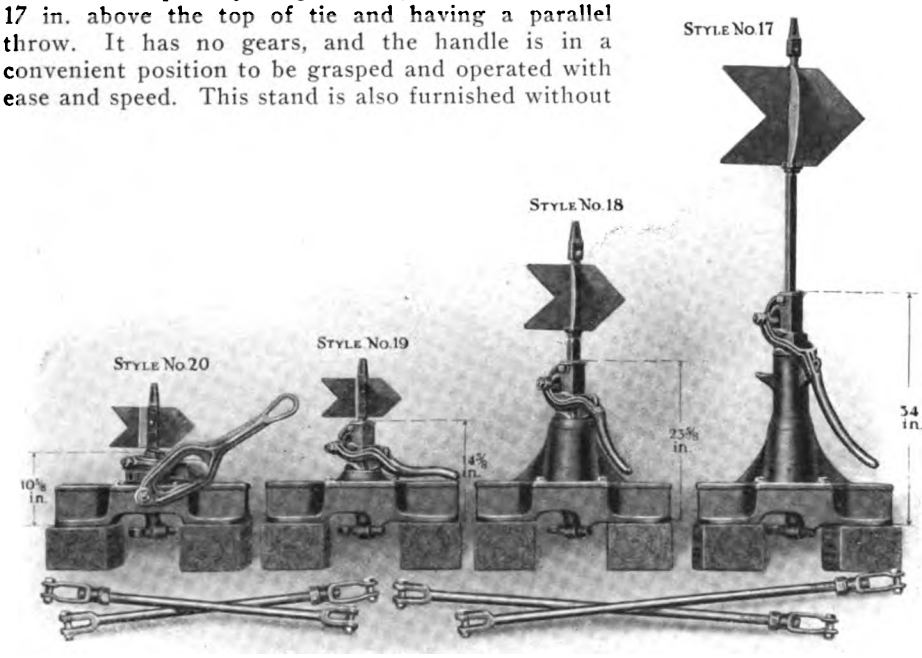
They are made in four general patterns. Style No. 17, thrown horizontally, is especially adapted for main line use. The handle is at the most convenient height for operation.

No. 18 is similar, but of medium height. It is adapted to either yard or main line use.

Style No. 19 is also similar in general construction, but is made as low as practical to adapt it for use where a low stand is required in yard or main line service.

No. 20 is especially adapted for yard use, standing 17 in. above the top of tie and having a parallel throw. It has no gears, and the handle is in a convenient position to be grasped and operated with ease and speed. This stand is also furnished without target and with short spindle for target disc lamp.

Each type is equipped with enameled target, adjustable throw and adjustable moving rod.



Ramapo Patent Automatic Safety Switch Stands

Automatic Mechanism

An exclusive feature of the operating mechanism, which is the same in each of the four patterns, is that it is absolutely rigid for hand operation and is always automatic whether locked or not. When the stand is locked in the wrong position a train trailing the switch operates it without breaking the switch points or their connections, thus reducing the cost of track maintenance. This is accomplished by a special construction whereby the spindle is held firmly in position by heavy springs, requiring a pull or push of over 2,000 lbs. on the switch connecting rod to start the automatic action, which action is not materially affected by the speed at which the springs are operated.

Sectional View of Ramapo Patent Automatic Safety Switch Stands Below the Cover Plate

The automatic feature depends upon the operation of the so-called "star" block, roughly described as a square block on the lower extremity of the spindle, having each of its four sides hollowed to give prominence to its corners, which form the points of the "star." This is normally held rigidly between two spring-actuated roller plungers, the rollers of which engage with the depressions in opposite sides of the star block, but which yield to the passage of the star points when the block is rotated, causing the block to snap over immediately when it is turned beyond the center by the movement of the switch.

The spindle or staff to which the target is attached extends from the crank at the base up through the switch stand and is connected with the star block by a sliding sleeve. When the handle is lowered the squared bottom of the sliding

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sleeve fits into a square socket on the top of the star block, with which it is then rigidly connected.

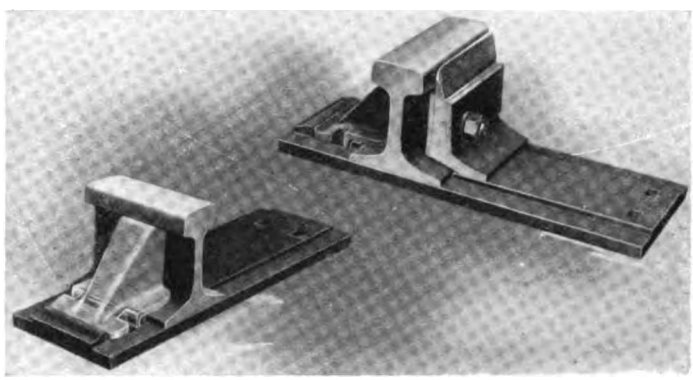
In hand operation the hand lever must be lifted. This raises the sliding sleeve, disconnecting it from the star block, when the spindle may be turned without revolving the star block. When the hand lever has been turned it will be impossible to lower it and the sleeve into the top of the star block, unless the switch point is snugly against the running rail, making the operation positive.

Summary of Principal Features

1. Positive Throw—Ramapo Automatic Safety Switch Stands are rigid for hand operation. The springs do not intervene between the operator and the switch points. When the handle is raised the spindle is released from the automatic mechanism. The switch may then be thrown, but the handle cannot be lowered or relocked unless the points are fully thrown.

2. Automatic Safety Features—A car or train may trail through a wrongly-set switch without breaking the points or injuring the stand. The first pair of wheels forces open the points, compressing the springs in the stand. When the points are half thrown the springs force them the rest of the way. The target and lamp go with the switch and indicate the new position. The stand remains locked ready for further hand or automatic operations without repair or attention of any sort.

3. Adjustable Features—All Ramapo stands are furnished with adjustable cranks and moving rods. Adjustable switch rods are not required, as all lost motion can be taken up in the stand and either point adjusted. The throw can be adjusted to suit any switch.



Ramapo Double Shoulder Solid Bottom Switch Riser Plate

Double Shoulder Solid Bottom Switch Riser Plates

Ramapo Double Shoulder Solid Bottom Switch Riser Plates have met with much favor, affording a positive hold on the stock rail in maintaining the gage, and have been standardized on many of the railroads.

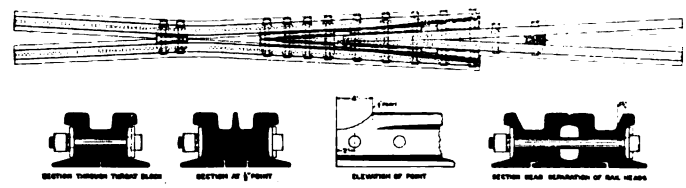
The illustration shows a plate having a minimum thickness of ¾ in. under the stock rail, a 7 in. bearing width on the tie and a riser 4½ in. wide under the stock rail, which is recommended for congested traffic. These plates are also furnished ½ in. thick under the stock rail and in 6 in. and 5 in. widths.

Adjustable Rail Braces

Ramapo Adjustable Rail Braces are designed to eliminate all lost motion of the stock rails on the first two or three ties under the switch points and facilitate positive adjustment of the switch throwing mechanism. They take the place of the large solid braces customarily fitted in the field by the signal department. They may be readily installed without disturbing the track and may be used with existing switch plates.

Wedge Adjustment Guard Rail Clamps

Ramapo Wedge Adjustment Guard Rail Clamps are made with a yoke of heavy special forged steel, providing ample strength for the severest service. They are easily applied and easily adjusted.



Ramapo Bolted Frog, Conforming to A. R. E. A. Standards

Standard Switches, Frogs, Crossings, Etc.

Other products are switches with manganese points, a construction which prolongs many times the life of the switch and adds very little to its cost when compared with the added life; switches conforming to the standards of the American Railway Engineering Association and the recommended designs of the Manganese Track Society.

Frogs and Crossings are manufactured with rolled manganese wing rails, of the railbound manganese steel type, solid manganese construction and open hearth construction. Other types are made to conform to A. R. E. A. and M. T. S. standards and to special designs.

Slip switches are built for interlocking connections or with operating devices complete, and heavy construction with heavy shoulder plates to meet the most severe congested traffic conditions.

Ramapo Railbound Manganese Steel Frog, Conforming to M. T. S. Standards.

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CHEMICAL WEED KILLER

"Herbicide"

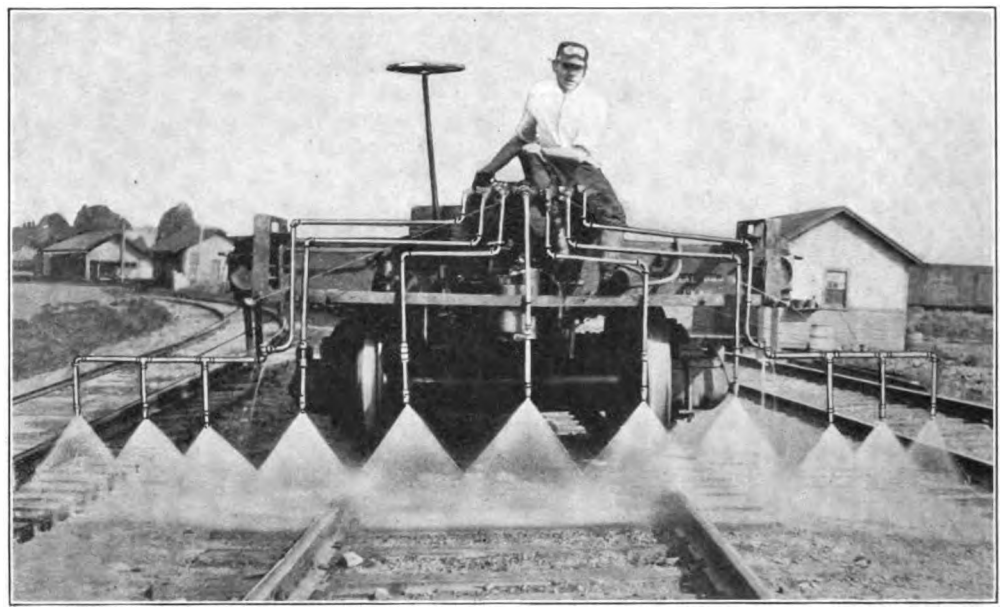
The chemical weed killer "Herbicide," extensively used by a large number of representative railroads for the purpose of exterminating the undesirable vegetation encountered along the roadbed is a liquid manufactured by The Reade Manufacturing Co., Jersey City, N. J. The action of the preparation is based upon the process of leaf absorption, the theory being that the poison applied to the leaves of the plants is absorbed and carried to the roots by the receding sap, the sap receding owing to the effect of the liquid as under the action of frost. According to the theory the plant is killed from the top downward and usually by less chemical than required where the roots are reached by soaking the soil.

application of the chemical to the undergrowth as well as that in sight. Where the growth is of medium density or scattered the speed is correspondingly increased to 12 or 15 miles.

The chemical is shipped in tank cars and 55 gal., steel drums, the tank cars being equipped so that they can be used as distributing containers, thereby lessening the amount of handling of the chemical required and eliminating the need of additional containers.

Advantages

The chemical is represented both as a substitute for labor, not always available, and as a more effective method than hand-weeding in that successive applications not only destroy the vegetation then present but discourage



A Reade Spraying Equipment Applying "Herbicide" to a Roadbed

Method of Application

The chemical is prepared for its application by diluting with an equal portion of water and is distributed over the roadbed by means of a special spraying device, consisting of a system of pipes, valves, strainers, and spray nozzles, adapted for mounting on any flat car and arranged so that application can be made to the whole or to any part of the roadbed covered by the spray. This control over the distribution of the chemical is of distinct advantage as a means of conserving the supply. The equipment assembled for mounting on a flat car can be made up at a cost approximating $300.

The piping on the flat car is connected with that on the tank cars by means of flexible hose. The air required for spraying of the chemical is maintained at 20 lb. pressure and is obtained from the train line, the amount used never exceeding eight cu. ft. per min., being insufficient to interfere with the proper braking of the train.

The rate of speed at which the system is carried over the roads is governed by the density of the vegetation. Where very dense, the speed is usually limited to 10 miles per hour in order to insure the

further growth. Records indicate that a single application per year will generally show economy over a single hand-weeding, and a correspondingly greater economy where it has been the usual practice to hand-weed two or three times per season. With the dilution effected prior to starting it is an ordinary occurrence to cover 100 miles per day including delays for traffic and other causes. On the basis of one man hand-weeding 300 feet of 16 ft. road bed per day, it would thus require 145 men two weeks to equal the performance of the spraying machine.

Contracts

The Reade Company makes contracts with the railroads which include the delivery of the amount of "Herbicide" required for the specified mileage, and a spraying system to be operated under the direction of a representative of the company acquainted with the various forms of vegetation encountered and the quantities of chemical required to insure satisfactory results. Where the mileage to be treated does not warrant the presence of a representative of the company, full instructions are furnished instead, this latter method working satisfactorily for roads familiar with the spray method of weed extermination.

THE READE MANUFACTURING CO., JERSEY CITY, N. J.

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General

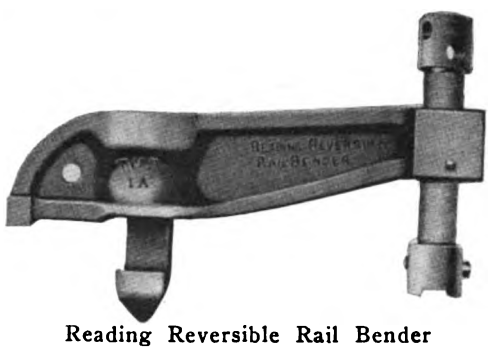
The Reading Specialties Company, Reading, Pa., is the manufacturer and distributor of the Reading line of rail benders and straighteners, car replacers, derails, guard rail clamps, compromise joints, rail braces, and tie spacers. These devices are made for the most part of cast steel, an advantage of which is the ability to concentrate the metal at the point of greatest strain. All metal entering into Reading products complies with the specifications of the American Society for Testing Materials as well as other commercial specifications.

Rail Benders

One of the problems confronting track men frequently is that of bending rails. For this purpose the Reading Company manufactures two types of rail benders, the Samson, and the Reversible. The Samson bender is of the non-reversible type, the frame and rail hook being

Reading-Samson Rail Bender

made in a single piece of cast steel. The screw is of rolled steel fitted with a jack-bar head and a swinging non-slipping rail cap, and the bushing in the frame through which the screw operates is of special bronze. The bender is made in five sizes: AA for all sections of T rails up to and including 150 lb.; A, for rails up to and including 100 lb.; B, up to 80 lb.; C, up to 60 lb, and D, up to 45 lb. All sizes except AA are provided with a hole in the frame for inserting a carrying tool. Sizes C and D are also provided with a handle.



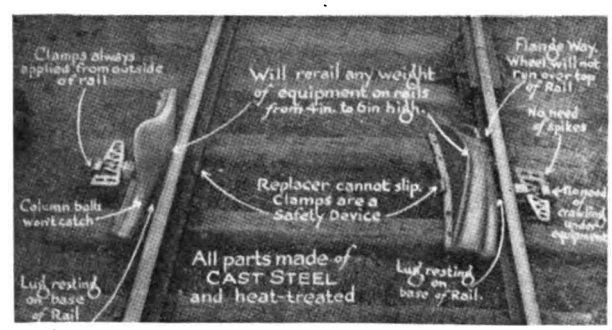
Reading Reversible Rail Bender

The Reversible bender differs from the Samson in having a reversible hook for bending rail to the right or left with equal facility. This type of bender is distinctive also in its unusually large working radius and in the feature of its construction which permits the bending of rail within nine inches of the end without requiring another section of rail and splice bars. This bender is made in two sizes, A for all sections of T rail up to and including 100 lb., and A1, up to and including 135 lb.

Car and Engine Replacers and Clamps

Car and engine replacers are of such importance on railroads as to constitute a part of the regular equipment of cabooses and engines of all trains, and of wrecking and construction outfits, and they are often also kept on hand in track tool houses to meet occasional emergencies. The Reading Company is particularly well known for its replacers, as many as four carloads of these appliances having been furnished on a single order. The devices are of cast steel, heat treated, and are of these types, and are made in the following types: Types A7 and A1 are designed for all axle loads up to and including 78,000 lb.; A2, for all axle loads up to and including 60,000 lb.; A, for all axle loads up to and including 63,000 lb.; B, for all axle loads up to and including 50,000 lb.; and D, for all axle loads up to and including 35,000 lb.

The Reading replacer clamp is the result of the company's effort to furnish a convenient, safe, and effective means of holding car and engine replacers in position. The clamps are applied from the outside and eliminate the need of spiking, an unhandy method at best and often a dangerous one. The



An Installation of Reading Car Replacers

clamp is of cast steel in three pieces. The slotted bar has a lip at each end, at one end to engage the rail or the flange on the replacer, and at the other to guide the wedge against the block in the slot of the bar, the block being forced by the wedge against the rail or replacer. The wedge is perforated to permit a spike or other tool to be inserted to prevent its slipping out.

Safety Derails

The Reading safety derails are portable and are designed to afford complete protection from accidental collision or entry by trains for men working under cars or on closed tracks. The need for such a device is indicated by the number of such accidents and the frequency of the practice of spiking switches. The device consists of a derail casting provided with stop sign and so designed that the derail is locked or unlocked by raising or lowering the stop sign which in turn cannot be raised in position unless the derail is properly placed on the rail.

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General

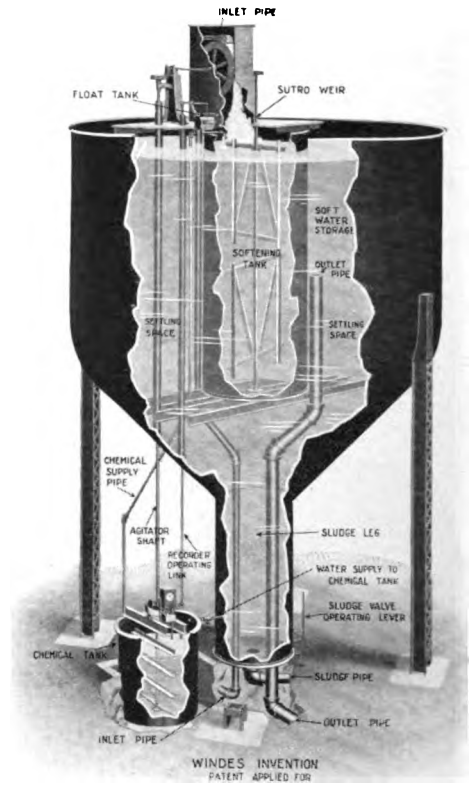
It is becoming generally realized among railway officers that the treatment of locomotive water supplies presents possibilities of effecting large economies under many adverse conditions. Practically all roads are forced to use waters which carry considerable quantities of alkalies, scale-forming minerals, mud, and other objectionable matter in suspension or solution and often the nature and amount of this matter is such as to constitute a source of much trouble and expense. The leaking or bursting of flues, the corrosion of boiler plates and stay bolts, the cracking of fire boxes, the burning of crown sheets, the clogging of branch pipes, injectors, super-heater elements, and feed water heating systems, the sticking of boiler checks, dry cylinders, foaming, defective steaming, and even engine failures indicate how subject steam boilers, and particularly locomotive boilers, are to the water carried in them. Prominent among the results which may be expected from the treatment of such waters are reductions in the expense of boiler repairs and in fuel consumption, longer life of equipment, reductions in the period in which equipment is kept out of service, the elimination of much cost and annoyance due to interrupted running schedules, and increases in effective power.

The Refinite Company, Omaha, Neb., builds two types of water softeners, the Refinite and the Booth, the latter system being taken over recently by the Refinite Company through the acquisition of the L. M. Booth Co., a concern which has occupied a prominent place in the water softening field for more than 20 years. The Refinite Company devotes its entire attention to the development of these systems together with pressure filters and is thereby equipped to solve the many problems arising in the treatment of railway water supplies. Its systems are used throughout the country in factories, power plants, laundries, public buildings, homes, and by municipalities and railroads. Refinite laboratories are located at Omaha, Neb., where those interested are invited to send waters for analysis. Sales offices are located in Chicago, New York City, Atlanta, Ga., Cincinnati, O., San Francisco, Cal., Spokane, Wash., Minneapolis, Minn., St. Louis, Mo. and Los Angeles, Cal.

Booth Systems

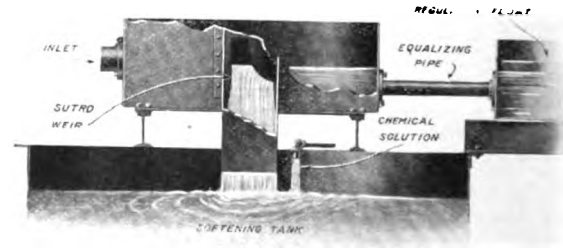
The Booth systems of water softening are especially adapted for use in the preparing of water for steam boilers on railroads. The water obtained for this purpose often contains a high concentration of scale forming salts or other objectionable matter, and usually required in large quantities, is generally pumped directly to the plant, and frequently is subject to wide and rapid changes in condition, considerations which usually call for special treatment. The Booth systems are of the continuous type, employ lime and soda as softening reagents, and are built in capacities ranging from 500 to 150,000 gal. per hour and up. The plants embody the results of an extended experience in the railway and industrial field.

In the coni-spherical bottom softener the Booth principle is applied particularly to the needs of railways in softening waters for locomotive use. In appearance this plant resembles the conical bottom steel water tank. The large settling tank is supported on structural steel posts and its bottom has the slope of an inverted cone which joins the tank body in a curve of short radius and terminates in a leg or riser pipe equipped at the bottom with a quick opening sludge valve. In this system the incoming water proceeds through a measuring weir to the reaction tank, a steel cylinder supported in the center of, and extending downward to within a



Booth Coni-Spherical Bottom Type of Softener on C., M. & St. P. R. R.

short distance of the bottom of the settling tank. In this tank the water receives its supply of chemicals and is constantly stirred by revolving agitators. Emerging from the bottom of the reaction compartment, the water distributes itself over the settling section and rises slowly to a point from which it



Booth Measuring Weir and Float Chamber

flows to pumps, or directly to elevated storage tanks, heaters, or track stand pipes. The settling tank itself provides considerable storage space above the outlet pipe and encloses the inlet, outlet, and chemical pipes.

The chemical apparatus is located directly below the tank, and consists of a steel chemical tank, chem-

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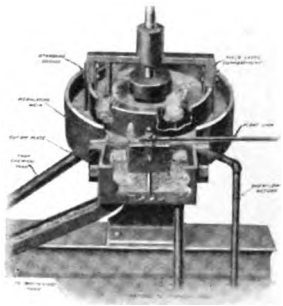
ical pumps, and a chemical regulator. The chemical tank has a capacity sufficient for fourteen hours full capacity supply of chemicals. It contains agitators arranged to keep the solution of uniform concentration during the operation of the plant. To facilitate the preparation of the chemical solution the tank is also provided with a notched scale so that at any time that it is desired to replenish the supply, the attendant has only to count the number of visible notches, fill the space with water, and add chemicals in proportion.

During the operation of the plant the chemical is pumped into the regulator by one pump and thence by a second pump into the top of the reaction tank. The pumps are simple solid plunger pumps designed to avoid annoyance or irregular feeding of chemicals resulting from leaking and are made to work against sufficient pressure to clear pipe lines of any deposit which may have formed during the period the plant is not in operation. The pumps operate by eccentrics, the power required by the pumps as well as the agitators being furnished by a water wheel or electric motor.

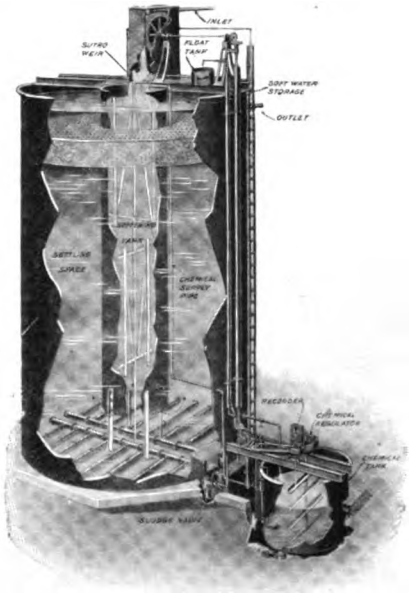


Chemical Regulator

The chemical regulator is a device having three concentric compartments and a distributing chamber. The chemical solution pumped to the regulator enters the middle compartment in which, by overflowing constantly into the inner compartment, it maintains its level at a fixed height. From this fixed level compartment the solution flows under constant head through an orifice and thence over a distributing weir. A cut-off plate moving along the crest of this weir divides the solution into two parts according to the quantity of crude water entering the plant, one part being pumped to the reaction tank and the other returning to the solution tank. The movement of the cut-off plate is controlled by a float in a float chamber above the settling tank, the water in this chamber maintaining the same level as that of the crude water passing over the measuring weir and this level in turn being directly proportional to the quantity of water flowing. The solution in the regulator is agitated constantly by paddles, operating from the same shaft which serves the solution tank. A meter mounted on the regulator and operated from the cut-off plate shaft charts the daily and momentary performance of the plant.

Advantages

This system possesses several advantages from the railway standpoint. Because the feeding of the chemicals is proportioned automatically to the quantity of incoming water, the system is able to adjust itself to the many variations in supply common to railway plants, such as a variation in the head in raw water supply tanks, the variable performance or unexpected stopping of pumps, etc. The automatic and continuous feeding of the chemicals to the water by a system which is simple and easy to keep in operation makes it less difficult to avoid irregularity in the condition of water due to neglect or temporary inability of the attendant to give prompt attention. Continual stirring of the mixture while in the reaction or softening tank, insures thorough mixing and greatly increases the effectiveness of the settling by coagulating the precipitates, as they form, in heavy masses, a very important item in softening some waters. The comparatively large diameter of the reaction tank and the manner in which the water emerges from it serves to distribute the water uniformly and prevent eddying currents from disturbing the settling region. The upward movement of the water, with the exceedingly slow rate of up-flow, provide for effective settling. The sloping bottom of the tank and the leg offer cleaning facilities which make it unnecessary to take the tank out of service at frequent intervals. The elevation of the soft water outlet ordinarily eliminates the need of pumping equipment other than that required for the unsoftened water. Finally the system requires but little housing except in regions subject to protracted cold and here the compact arrangement of the plant makes heating a relatively simple problem.



Booth Flat Bottom Type Softener

Where the nature of the water is such as to require a longer period of mixing or where a filtering medium is desired to supplement the settling chamber, the Booth flat bottom tank can be furnished instead of the conispherical type. The sludge system consists of a collection of perforated pipes arranged and proportioned to remove the sludge uniformly from all parts of the tank bottom.

The Refinite System

The adaptability of the Refinite system for preparing water for use in steam boilers depends upon conditions and the water. Where the raw water carries a considerable amount of scale forming salts, a combination Booth and Refinite system is recommended. The carbonates are removed by lime in the Booth system and softening completed by Refinite.

Refinite is a natural mineral, known scientifically as Zeolite which has the property of exchanging the sodium, for calcium and magnesium in water. After the mineral has completed its softening capacity, it is regenerated by adding a salt solution to restore it to its original state.

The system is compact, requiring little attention, is free from cumbersome devices, and is clean and economical in operation.

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General

The Reliance Manufacturing Company makes only nut locks but is one of the largest manufacturers of this product in the world. By devoting its entire attention to this single item among auxiliary track fastenings, it has been able to effect many improvements, until today the quality of Reliance nut locks and lock washers is recognized practically everywhere. As many as 130 million Reliance nut locks have been produced in a single month, and the average is close to 100 millions.

Nut locks, or spring washers as they are sometimes called, have played an important part in railroad track maintenance for a great many years. From time to time certain of the roads, acting on the belief that nut locks were an unnecessary part of the track joint, have discontinued using them; but in practically every case, they have returned to their use after a further period of investigation. It has been proved that nut locks not only save money by prolonging the life of the bolts, but that they provide a more uniform degree of bolt tightness, thereby causing each of the bolts to carry equally its part of the strain imposed by the traffic. They perform a further duty by acting as a cushion between the bolt and the angle bar, avoiding bolt breakage.

The plant of the Reliance Manufacturing Company at Massillon, Ohio, is exceptionally well equipped for the manufacture of nut locks. The latest and most modern methods are employed scientifically, not only in the manufacture but also in the heat treating of the nut lock, insuring uniformity of the product, besides full durability of the reactionary power, which is the true test of any spiral spring nut lock. The company's main office also is at Massillon, Ohio, while branch offices are maintained at New York City, Chicago, Cleveland, Ohio, and Detroit, Mich. An office for the Pacific coast is at San Francisco, Calif.

Reliance Nut Lock Manufacture

The Reliance Manufacturing Company maintains and operates its own steel plant, and is in a position to furnish nut locks made to the High Carbon Pennsylvania Steel Spring specification, the analysis of which is as follows:

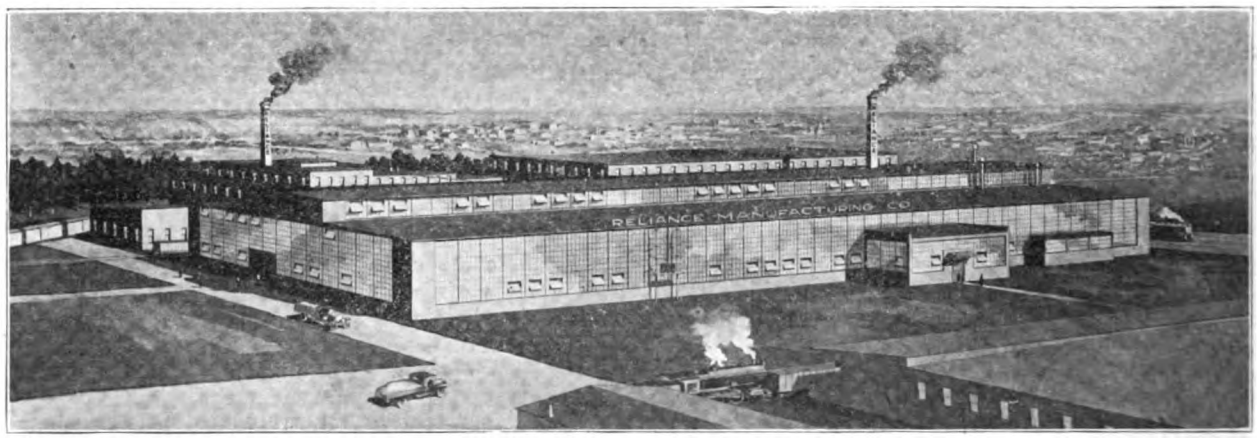
Carbon	.90 to 1.10
Manganese	.40 to .50
Phos.	under .05
Sulphur	under .05

During the past few years, alloy steels have come more and more to the front, due to the fact that they resist fatigue, and have a higher tensile strength and elastic limit.

At the time this Cyclopedia goes to print, The Reliance Manufacturing Company is in the midst of completing its test of a nut lock made of a special analysis of alloy steel which will give higher pressures through a greater distance than nut locks made from carbon steels.

By virtue of having its own steel plant, the company is in a position at all times to make prompt delivery, as it is not wholly dependent on outside sources for raw material.

The Reliance Manufacturing Company will be glad to furnish upon request, reasonable quantities of nut locks for test purposes, made from this special alloy steel, and, at the same time furnish laboratory data of compression and reaction readings.



The Reliance Steel Plant at Massillon, Ohio

Nut Locks are made in large quantities, and it has always been a more or less difficult proposition to get a uniformity of heat treatment, but this condition has been overcome by The Reliance Manufacturing Company, not only in furnace design, but also by tumbling the nut locks after the hardening operation, to remove the scale and oil, so that they may more readily absorb the proper drawing heat to bring them to the required spring temper.

Reliance Nut Locks

Parallel Pattern, 3/8x1/4 in. High Tension, 3/8x3/8 in.

The bars are wound spirally on short bars and

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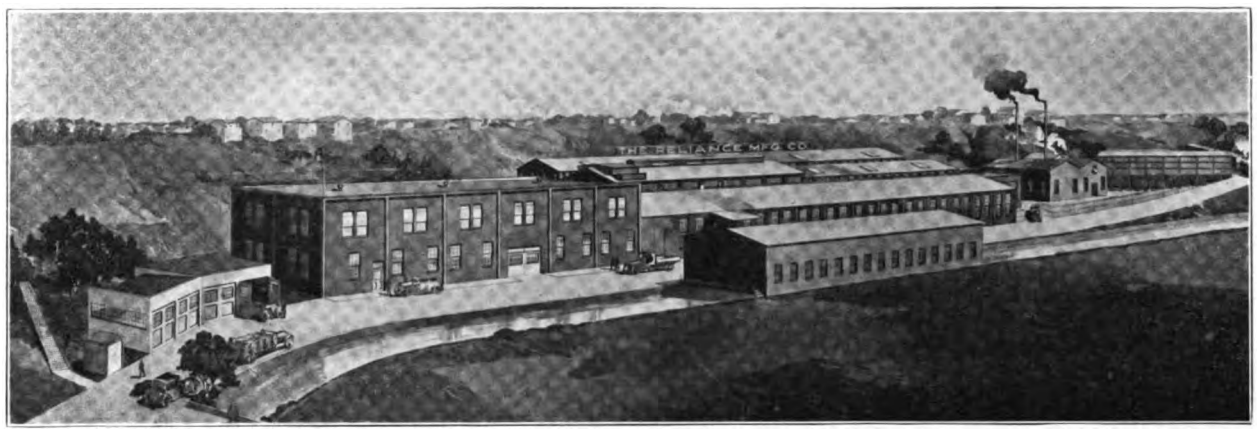
sheared successively along the top line of the bar; or the fabrication may be done on automatic machines.

The nut locks are then hardened by a careful heat treatment under pyrometer regulation, which not only is checked frequently, but is definitely recorded locks are then quenched in oil, are tempered, and are then ready for the final inspection and test of the works.

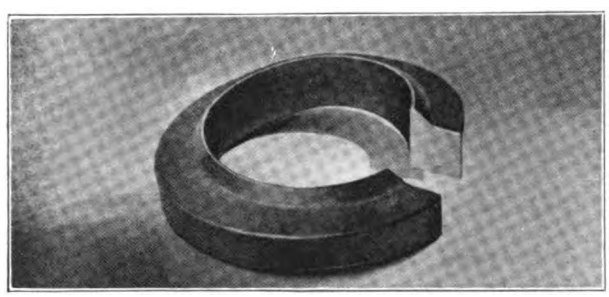
This test consists of both a compression and a break test. A sufficient number of nut locks from each furnace are compressed until flat and the return to spiral shape noted. These nut locks are then broken and the homogeneity of the steel observed. Unless the nut lock returns nearly to its original shape, or if the fractured area is not clean, the nut locks from the entire heat are discarded. Upon passing these tests, Reliance nut locks are ready to go out with the company's guarantee that they are commercially perfect as regards both material and workmanship; and a further guarantee is given that any nut locks which prove defective will be replaced, or the purchase price refunded.



The Reliance Nut Lock Plant at Massillon, Ohio

Reliance Nut Lock Design

The design of the nut lock is of special importance in track work to avoid the possibility of torsional strains being introduced. To provide a rectangular section in the finished nut lock, Reliance nut locks are made of keystone-shaped steel, because of the drawing out of the outer face of the spiral, and the compression of its inner face.



Reliance Nut Lock—Rib Pattern

The inside diameter of the nut locks governs to a large extent the section of steel that may be used, and consideration must also be given to the way they will be applied under the turning motion of the nut. Sharp gouging points cannot be present without the resultant spreading of the steel, which destroys the spring action of the device. After careful study of the requirements of nut locks as part of the track joint the Reliance Manufacturing Company has recommended for general practice the following sections: (1) For bolts requiring nut locks of a diameter from ¾ in. to ⅞ in., the ⅜ x ¼ in. parallel face pattern, in which the steel to be coiled is of ⅜ in. by 13/64 in. by 17/64 in. section, which gives an absolutely parallel face nut lock, eliminating the chance of a sharp cutting edge gouging the nut; and (2) for bolts requiring nut locks of a diameter from 15/16 in. to 1¼ in., the ⅜ x ⅜ in. pattern, which is also made from keystone, shaped steel ⅜ in. by 23/64 in. by 27/64 in. section.

While the flat or plain pattern of nut lock is generally preferred, as affording the maximum of spring activity for the amount of material employed, the Reliance nut locks are made also in the ribbed, the positive, the tail and the high collar patterns. The stamping of the barb in the positive pattern must, in the present state of the art, be done with hand labor. The ribbed pattern is frequently desired for lighter service, and the high collar for use about frogs.

About sixty different sections of bars are used in the various designs of Reliance nut locks, and the nut locks are made in all practical sizes required. For railroad use, they are generally packed 1000 in a keg.

The upstanding points in the manufacture of Reliance nut locks are: Steel made specially to the company's own analysis; a proper proportion of width and thickness to coordinate with the size of the bolt; careful inspection of the manufacturing operations; and correct heat treatment under pyrometer regulation.

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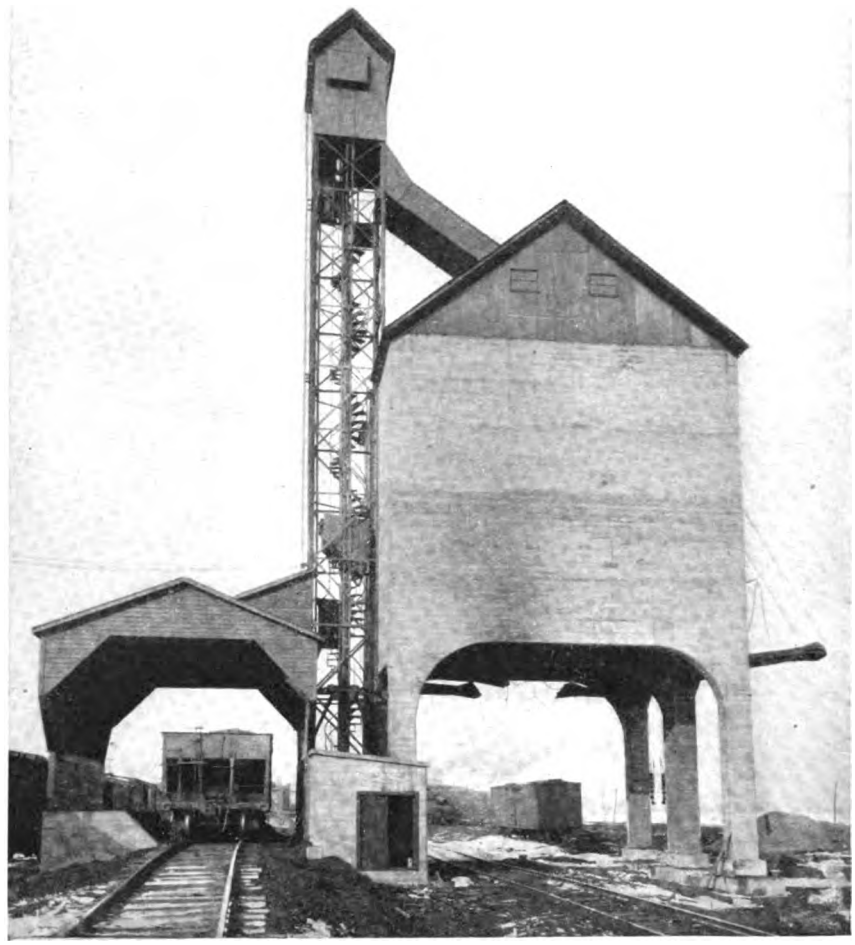
General

The Roberts and Schaefer Company, Engineers and Contractors, renders a comprehensive, experienced and efficient service in the design, construction and installation of complete "Locomotive Coaling Plants, 'RandS' Gravity Sand Plants, Cinder Handling Plants, Material Transfer Plants" and other similar storage and handling installations. The company was organized in March, 1904, and has thus completed more than 16 years of engineering service. It has established on many important roads a reputation for advanced design, superior equipment, correct methods of construction, dispatch and financial responsibility, which is unquestioned.

The operations of Roberts and Schaefer Company are among the largest of any in the United States in its particular line of engineering and construction. A successful business has been maintained continuously, in which performance has justified the well-founded confidence of the railways. A feature of this service has been the furnishings without cost of designs and proposals on Locomotive Coaling Stations built complete and ready for operation. This is supplied simply upon request accompanied by a plan of the track layout and a statement of the general requirements of the service.

The Roberts and Schaefer Company is a pioneer in the construction of Coaling Stations of substantial design and having labor saving equipment as a feature of the installation. Its engineers have been active in advancing the application of reinforced concrete to Coaling Station construction. The company was among the first to make use of the balanced and counterbalanced bucket type of coaling plant and devised a means for employing the bucket type in coaling plants having a 12-ft. shallow pit.

Distinctive features in the equipment of the more advanced type of Coaling Plant are the use of electric current for the automatic operation of the elevating equipment, a silent traction two-groove hoist for positive operation of the bucket, and a means of measuring and recording, by a power operated machine, the coal issued to the locomotive. The employment of the "RandS" Gravity Sand handling equipment in connection with Coaling Stations to eliminate the labor or hand shoveling is increasing as the economy of this service becomes appreciated.



Reinforced Concrete, 500-ton Capacity, Automatic Elec. Locomotive Coaling Plant, Designed and built by Roberts & Schaefer Company for Pere Marquette R. R. at Grand Rapids, Mich., in 1918

As demonstrating the extensive operations of Roberts and Schaefer Company it may be stated that this company has designed and built for a single railroad system 33 locomotive coaling plants, of storage capacities varying from 100 tons to 1200 tons, with a total combined capacity of 16,680 tons. Also in the two years, 1917 and 1918, the company built or contracted for 67 locomotive coaling plants distributed among many leading railroads throughout every section of the country. This large and extended business supplies indisputable testimony to the character of its service.

The Roberts and Schaefer Company completed in 1918, what is said to be the largest railroad coaling plant in the world. It is located at Philadelphia, Pa., on the Philadelphia and Reading Railway. It has 2000 tons storage capacity with facilities for coaling on six tracks. An extension sand storage plant is operated in connection with this station. The coaling station shown in the illustration was duplicated by the Pere Marquette at Saginaw, Mich., in 1920.

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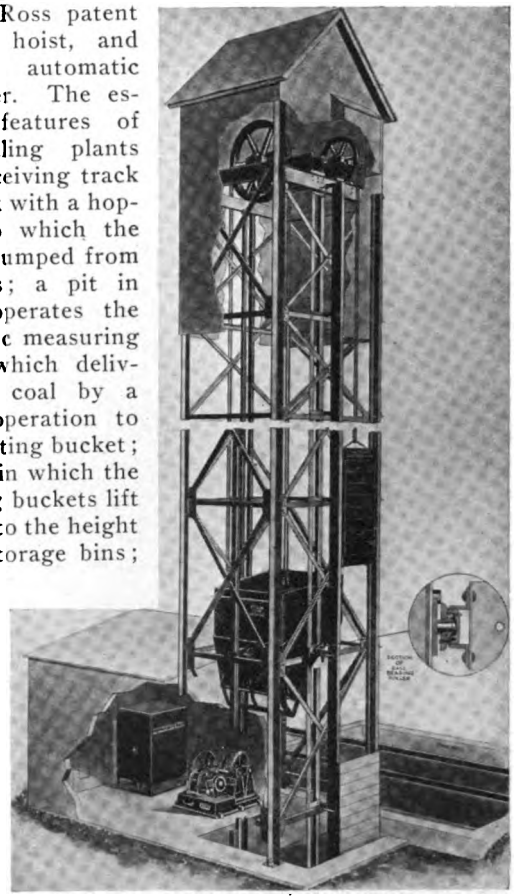
Coal Handling Equipment

The diagrammatic engravings illustrate the more common types of "RandS" Coaling Plants for different situations and services, and a typical layout of machinery for operating them, consisting of ball-bearing coal bucket, balancing counterweight, Ross patent traction hoist, and enclosed automatic controller. The essential features of the coaling plants are a receiving track equipped with a hopper into which the coal is dumped from the cars; a pit in which operates the automatic measuring feeder, which delivers the coal by a simple operation to the elevating bucket; a tower in which the elevating buckets lift the coal to the height of the storage bins;

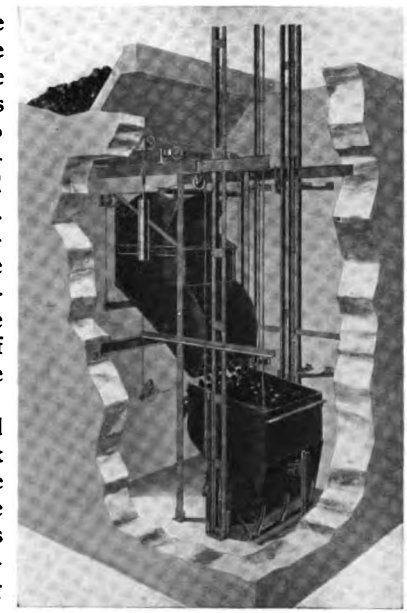


Lay-out of Machinery for "RandS" Coaling Station

a tram car system for the distribution of the coal from the elevating buckets to its required place in the storage bins; and a design of floor for the bins by reason of which the coal will run by gravity to one or both sides for discharge into the tenders. In the case of shallow pits where a depth of not more than 11 ft. is available the feeder is omitted and the elevating bucket travels through a bend in its guides from the elevating tower to the track hopper for its supply.

The Schraeder Feeder, patented on August 26, 1913, supplies the automatic measuring feature of the Roberts and Schaefer systems of coal handling. It is of heavy steel construction and has a measuring capacity for the largest sized buckets of 2½ tons at one charge. The coal which has been dumped into a receiving hopper emerges by gravity into the feeder through an undercut gate which is operated automatically by a ⅝-in. cable. When filled to its capacity, with the elevating bucket in the correct position, the load is discharged into the latter through the lower feeder gate which is also operated automatically.

The gates in the Schraeder feeder close tightly and there is no leaking out of the coal. Further, because of the automatic feature, it is not possible to reload a loaded bucket. The supports of the feeder are made of steel angles and channels, no wood whatsoever being used in these units. The device is efficient and at the same time simple through the entire absence of all levers, toggle links, etc.

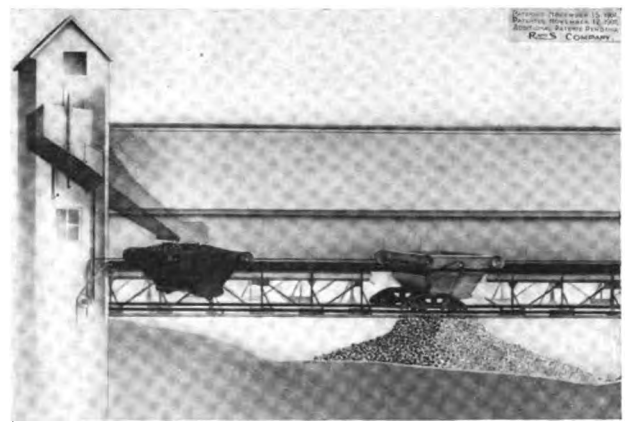


Schraeder Feeder and Bucket

The standard elevating bucket is of the same capacity as the feeder and is filled by the automatic opening of the lower gate of the feeder. The bucket travels up the steel elevating tower on heavy enclosed Gurney ball bearing rollers which are self-oiling. A 6-in. steel roller on the bucket apron, running on a continuous steel guide between the bottom of the pit and the bucket discharge point, avoids any possibility of the bucket coming down open.

The design of the bucket permits the coal to slide out when discharging into the bin on a straight line with the chute. There are no latches, trippers, closing springs, dumping curves or any similar mechanism. The operation of the elevating bucket and feeder are automatic. The construction of these two units, as well as of the elevating tower, is entirely of steel and obviates failures due to lack of adjustment.

The horizontal distribution of the coal to the bin is effected in several layouts by the addition of the simple "RandS Automatic Tram Car" system. The in this system is built throughout of ¼-in. steel plates and is 6 ft. long by 6 ft. wide, rolling on 16-in. cast iron wheels with hard babbitted bushings. The



The "RandS" Tram Car

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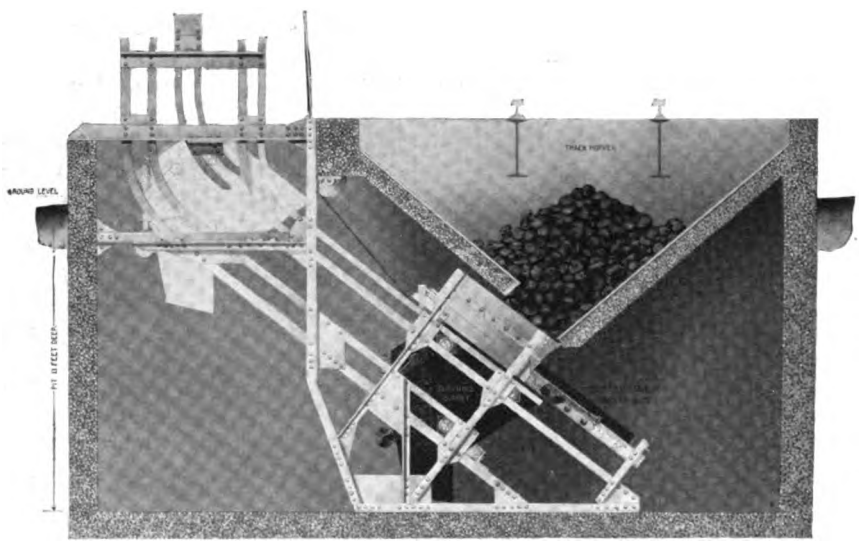
location of the roller wheels at the top, above the center of gravity, prevents the car from leaving the track. The tram car is self-discharging and self-closing and is entirely automatic in the discharge and closing operation, the discharge of coal taking place wherever the incline dump cam casting may be located. The roller on the pendulum gate comes in rolling contact with this cam opening and closes the doors positively and silently, permitting the discharge of coal from the Tram Car direct into the bin. The coal may thus be discharged over bin at any point in the path of the car. The dump cam casting is portable and arranged with substantial means for clamping to its supporting rails at any point desired.

The tram car is connected with a ½-in. hoisting cable to the hoist drum, which is direct connected to the bucket hoisting drum by drive gears. The horizontal travel is therefore timed with the vertical travel of the buckets. The tram car makes its complete trip horizontally as the buckets are being elevated. There is thus a tram car at the bucket discharge point to receive the coal as it leaves the elevating buckets.

For shallow pits which extend not more than 11 ft. below the base of rail of the coaling track the Roberts and Schaefer Company has a new design which it terms the "RandS" patent shallow pit coaling equipment. In this design the coal elevating bucket rolls up the tower through a 45-deg. bend in the guides on Gurney ball bearing rollers, and is so designed that it takes its load directly from the track



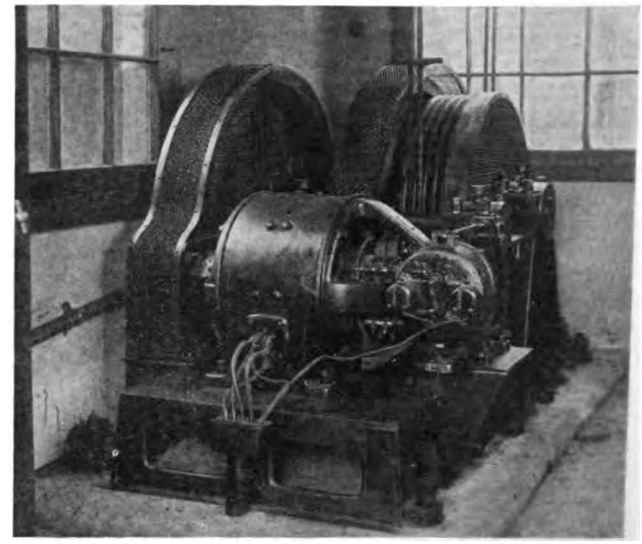
"RandS" Shallow Pit Coaling Equipment

hopper without the intervention of a coal-measuring feeder. An undercut gate operating on rollers, actuated by the ascent and descent of the elevating bucket, loads the bucket accurately, preventing the coal from overflowing and filling the pit.

A modification of the automatic measuring feeder type for pits as shallow as 12 ft. is the Duplex Patent Shallow Pit Feeder which feeds coal from the track hopper to balanced or counter-balanced elevating buckets. The hoist has a differential action with a ratio of travel of 5 to 1 for the loader and the elevating bucket. The loader is geared direct and definitely to the automatic electric hoist which likewise controls the elevating coal bucket.

Hoists for Coaling Stations

For coaling plants handling a large tonnage the Roberts and Schaefer Company recommends the cast iron base type of hoist, direct connected to an electric motor with solenoid brakes. Two types of hoists are supplied, one



Ross Patent Traction Hoist

with a single drum to elevate the bucket only and the other with a supplementary drum to operate the horizontal "RandS" tram cars. The solenoid brake prevents the dropping of the bucket in case the current is cut off. The brake sets fast at the bucket discharge point, being actuated by an automatic controller.

The design of hoist, exclusive with the Roberts and Schaefer Company, is the Ross Patent Traction Hoist, which is direct connected through machine cut spur gears and Falk herringbone gears to a General Electric or Westinghouse 15-hp. or 22-hp. alternating current or direct current motor, operating with the Roberts and Schaefer Automatic Controller, as manufactured by the Cutler-Hammer Manufacturing Company, the hoist being provided with solenoid brake. This electric equipment automatically regulates the different operations, permitting the continuous ascent and descent of the elevating bucket without an attendant. This feature contributes materially to the low labor cost per ton of delivering coal with "RandS" equipment.

The hoist is mounted on one large cast iron base assembled and lined up in the shop and is compact in its design. The drum consists of four deep V-grooves, two of which are used at a time. The grooves are so arranged as to be easily replaced without dismantling the hoisting cable. Two ¾-in. special steel cables connect the elevating bucket and the balancing counterweight and, through the two-

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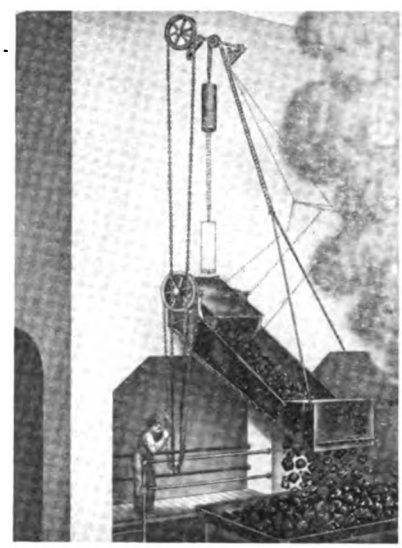
groove traction principle of the hoist, it is not possible to raise the bucket above the discharge point. This hoist is safe in operation because in case of an overrun at the top or the bottom either the bucket or the counterweight bottoms on a buffer, thereby reducing the traction on the hoist drum sufficiently to prevent further motion of the bucket and counterweight, even if the motor keeps on running.

Where it is desired to sort coal according to sizes the company is prepared to equip any plant with electrically-operated shaking screens to screen all coal prior to storing it in the pockets. The coal may be divided into lump coal and stoker coal, which ordinarily is required to pass through 2-in. perforations. If desired the lump coal can be withdrawn from the pockets by gravity, crushed, re-elevated, and discharged into the coal bin for stoker use.

Coal Delivering Devices

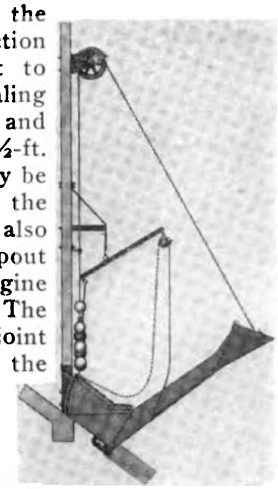
The means of delivering coal economically to the tender has also engaged the attention of the engineers of the Roberts and Schaefer Company. As a result the Safety-First Coaling Gate has been developed with a heavy hooded spout, controlled by the fireman on a platform level with the top of the tender. In this design, the undercut coaling gate does not depend upon a balancing counterweight or upon its own weight to close itself, but is under the manual power of the operator at all times through the rack and pinion and operating chain.



"Safety First" Undercut Coaling Gate

The Sway Coaling Apron with radial gate is another type of delivery chute made by the Roberts and Schaefer Company for the coaling of engines. It may be operated from the top of the engine tender with one hand from any position adjacent to the gate, this being made possible by a well-designed system of operating levers. The counterweights prevent jar when the apron reaches the limit of its elevated position as the differential weights retire to the structure for their support, while, when they are needed to balance the apron in the delivering position, they are in suspension on the operating chains.

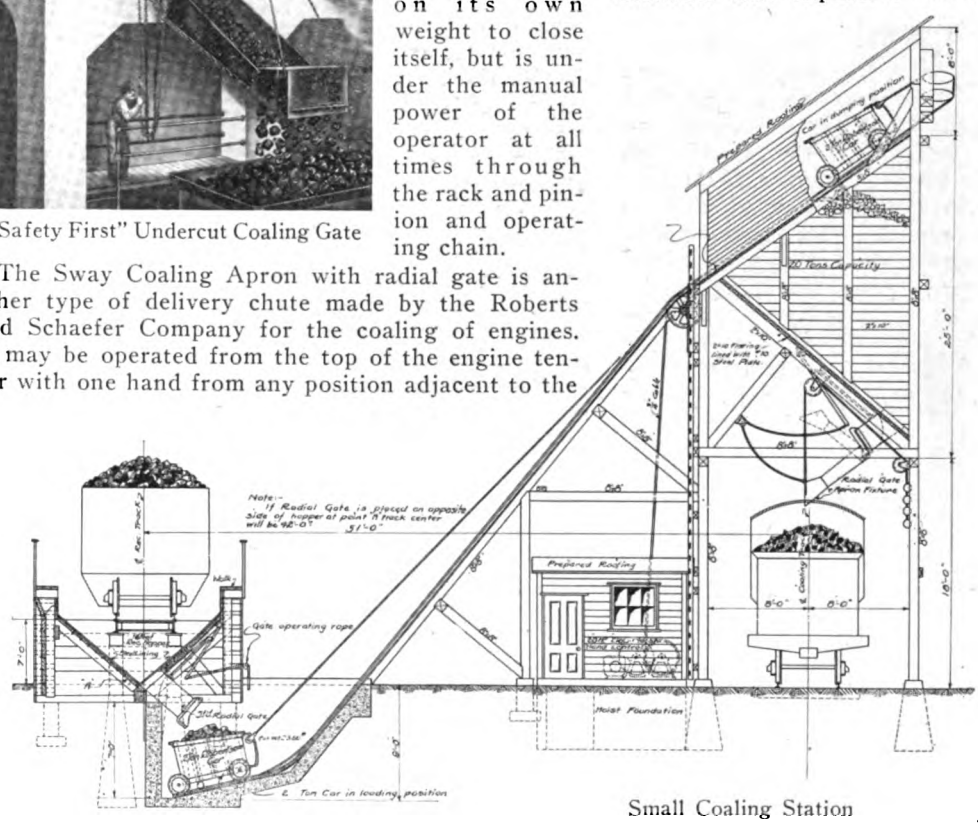
The Radial Gate is pivoted and cuts with the flow of the coal. It is positive in its action and prevents any attempt to skim the lumps. The coaling apron is pivoted laterally and allows a spread of coal 7½-ft. wide, by which a tender may be filled with one spotting of the locomotive. This feature also prevents damage to the spout or structure in case an engine moves while taking coal. The apron has a breaking joint which avoids demolition of the appliance. The gate is made with 24-in. high openings in the pockets, reducing the liability of the bridging of coal.



Radial Gate with Sway Spout

Design for Small Coaling Station

The Roberts and Schaefer Company has developed an economical coaling plant of frame-construction for less important points where the larger investment for permanent construction is not warranted, but where it is desirable that expensive shoveling methods should be discontinued. The design provides for a 20-ft. track hopper of frame construction built 7-ft. above the ground with bottom sloping to the center where a standard undercut radial gate is located, operated with a lever from the ground level. The coal discharges by gravity from this hopper into a two-ton Robertson car standing at the hopper opening. By means of a twenty horsepower direct-connected electric hoist with hand electric controller, this small car is then elevated to the top of a 20-ton frame-constructed pocket, where it is automatically discharged and the car returned to the hopper.



Small Coaling Station

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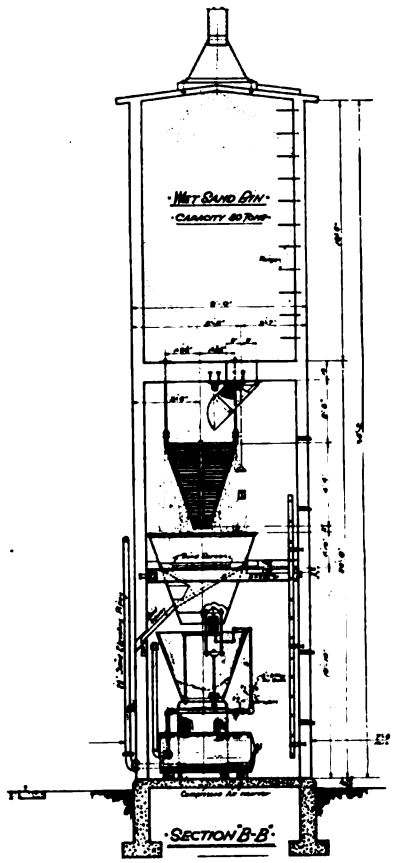
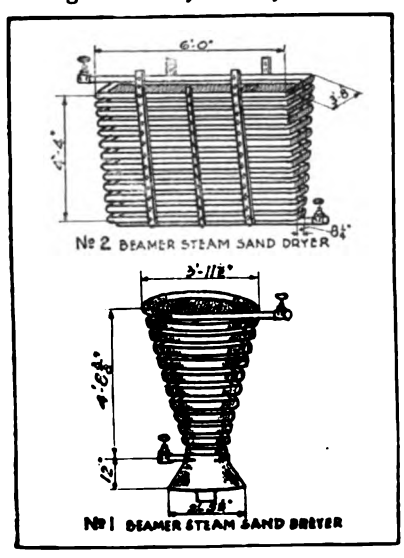
RandS Gravity Sand Plants

The operation of delivering sand to the locomotive at engine terminals is coincident with the coaling of the tender. At many plants the means of supplying both commodities is included in the same structure. The Roberts and Schaefer Company originated the gravity system for use in conjunction with coaling plants by which the sand is handled without manual labor, thereby reducing greatly the cost of the service, besides assuring proper preparation of the sand.



"RandS" Gravity Sand Plant

In the typical design of sand plant of the Roberts and Schaefer system the wet sand is dumped in the receiving hopper in the same manner as coal, hoisted in the elevating bucket and discharged by gravity through a chute into the wet sand bin. The green sand then flows directly to the sand drier, from there over a sand screen and into a drum from which it is forced upward by compressed air into the dry sand storage bin. By this system the entire process from dumping to delivery on locomotives is done without any hand labor whatever, which greatly reduces the cost of operation.



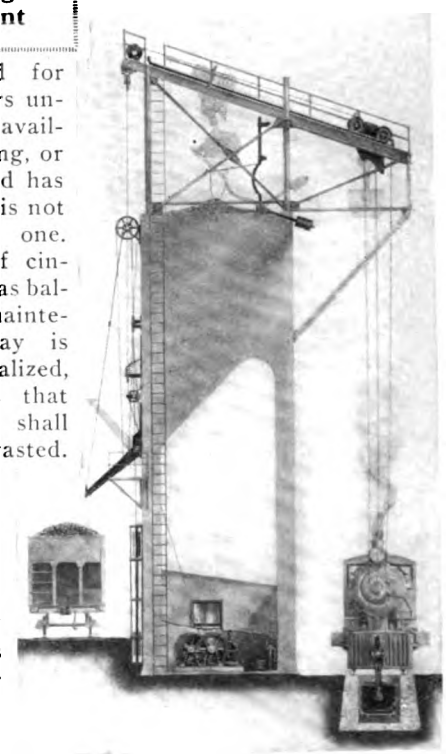
A feature of the "RandS" sand plants is the Beamer Patent Steam Sand Drier. In this the steam pipes are coiled in the shape of either an inverted truncated wedge or a cone. The pipes act as retaining walls to hold up the sand while wet but do not interfere with the contained sand running through the crevices between the pipes after it has been dried. The moisture escapes into the atmosphere, preventing rusting of the pipes or burning of the sand.

A further feature of the "RandS" gravity sand handling plants is the automatic sand drum. It is built with a substantial steel hopper over the drum, widened at the top like a funnel to gather in the sand from the cleaning screen. By the use of an air valve air pressure is released, moving the piston in the cylinder which opens the valve in the air drum, allowing the sand to run by gravity into the drum. By opening another valve the operator releases compressed air from the reservoir into the sand drum, forcing the dry sand through the elevating pipe to the dry sand storage bin above. It requires only a minute at a pressure of about 80 lb. to elevate a drumful of sand.

The moisture proof sand valve and dome spout is a useful adjunct in the delivery of dry sand to the locomotive.

Cinder Handling Equipment

The need for storing cinders until cars are available for loading, or until a carload has accumulated, is not an unusual one. The value of cinders for use as ballast in the maintenance of way is generally realized, and requires that this material shall not be wasted. Two types of cinder-handling equipment have been developed by the Roberts and Schaefer Company. The cinders are dumped by the engine directly into heavy cinder buckets holding about 2 cu. yds. each, which buckets are moved lengthwise in the pit on heavy roller trucks. In one form of installation these buckets are picked up by an electric hoist and moved over an inclined carrier to a given height above the cinder bin where they discharge automatically. In the other, the buckets are lifted vertically to the height of the bin and then move over to the discharging point above the bin.


"RandS" Cinder Handling Equipment

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General

The St. Louis Surfacer & Paint Co., St. Louis, Mo., manufactures a line of paints adapted to the proper maintenance and protection of all classes of railway properties, including rolling stock, bridges, buildings, tanks, signaling towers, semaphores, switch stands and the like. Its products, sold under the trade name Surpaco have been in successful use on many of the foremost railroads in the United States for years, a fact which indicates that they are maintained at a uniformly high quality. As every Surpaco product has its specific uses, an engineering department is maintained to advise on painting problems and to recommend the paints best suited to the particular needs. The paints are sold direct from the factory in barrels and tin containers. Generous working samples are furnished on request.

Railway Bridge Painted with Surpaco Metalsteel

Surpaco Metalsteel

Among the more important Surpaco products now being used by roads throughout the country is Metalsteel. Compounded on a pure linseed oil base, this paint is specially prepared to penetrate the pores of iron and steel and to form a tough, elastic and strongly adhering film of high preservative value. It is proof against blistering, peeling or cracking under severe service and affords a high resistance to the action of wind, water, heat, cold, gases, fumes, engine blasts, and other corrosive or wearing agents. The paint is furnished in any color, and is used for preserving bridges, steel tanks, standpipes, water columns, signal towers, switch stands, and all exposed metal surfaces generally.

Surpaco Target Enamel

Surpaco Target Enamel is specially prepared for painting block signals, semaphores, and switch targets. This paint is furnished in standard and in special colors. It offers a high degree of resistance to the destructive forces regularly encountered by paint in this service, has an elasticity which enables it to maintain its surface for long periods under all conditions of exposure without peeling or cracking, and will not fade in color. The last item is of particular importance in this service, the day target constituting one of the vital elements of the signal service.

Surpaco Station and Building Paint

Surpaco Station and Building Paint is a high grade and moderately priced paint specially adapted for use on freight and passenger stations, freight sheds and section and tool houses, by reason of its long wearing qualities and extensive covering power. It is furnished in all colors, flat, egg-shell or gloss finish, for outside body painting, outside trimming, and for inside ceiling and wall coats.

Surpaco Pole Paints

For the painting of poles the company makes two kinds of paint, one for steel and the other for wood posts. In both cases the paint is prepared to provide an effective protection to the pole and to improve its appearance. Surpaco Metalsteel Pole Paint for steel poles has been put to test on many of the largest lines in the country and is the subject of favorable service records for high elasticity, durability and fastness of color. The paint is not expensive, usually costing less than the labor necessary to apply it, and requires but infrequent renewals.

In the manufacture of the Surpaco Pole Paint for wood poles, the company has succeeded in providing a paint that is proof against blistering, cracking and peeling, and which will afford a high degree of preservation to poles from rot and decay under any climatic conditions. This paint is furnished in a variety of colors.

Surpaco Concrete Paints

For painting concrete surfaces, the company manufactures two kinds of paint, one for floors and the other for exterior and interior walls. Surpaco Concrete Floor Paint forms a hard, smooth surface for concrete, capable of withstanding the action of steam and water for long periods, and the hard usage to which a floor is ordinarily subjected.

Surpaco Exterior and Interior Concrete Paint for walls and ceilings is made by a special amalgamation process, of pure pigments and carefully selected ingredients. It is also capable of presenting a very durable surface to steam, water and the action of the weather; it does not peel and is fast in color. It is a particularly economical paint for concrete walls and ceilings, both from the standpoint of initial cost and permanence. It is supplied in flat or gloss finish to match any color.

Surpaco Leads

The company furnishes both white and red leads Nos. 313 and 314, respectively, and a special railroad metal lead, No. 315. The latter material is adapted for uses either as a primer or for second-coat work. It is fast in color, and does not crack or peel under severe service.

ST. LOUIS SURFACER & PAINT CO., ST. LOUIS, MO.

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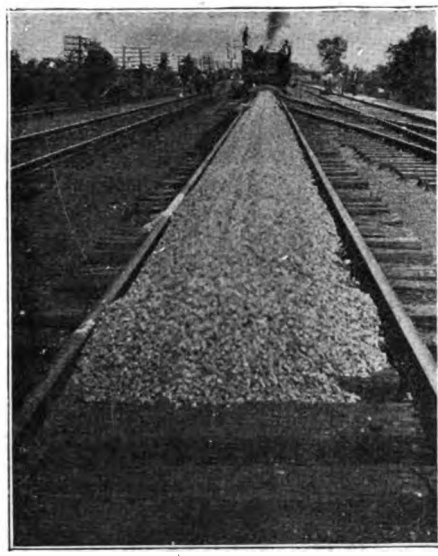
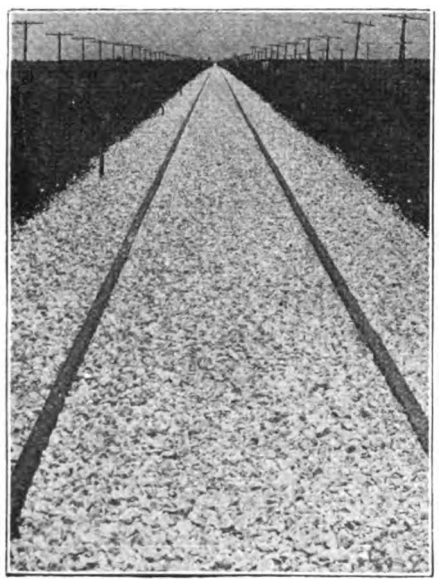
Ballast Cars a Labor Saving Device

The almost universal method of unloading ballast is by dumping it from cars into the center, or to one or both sides of the track. Whether the work is the ballasting of new track, the reballasting of old track, or back filling after the season's overhauling, the work is done most efficiently by gravity, with shoveling reduced to a minimum. The opportunity to occupy a track during the time needed for unloading the material can only be afforded with some sacrifice and expedition is always desirable, but, of greater importance, the unloading must be so governed that the track will not be left obstructed after the material has been dumped. The time required to shovel the rails clear, or the danger of derailment when ties are used to keep them clear, not to mention the slid-flat wheels which result from the latter practice, have relegated the older methods to the discard.



Center Dump Ballasting with Hart Cars. A Uniform Disposal of Crushed Stone as Placed by the Cars.

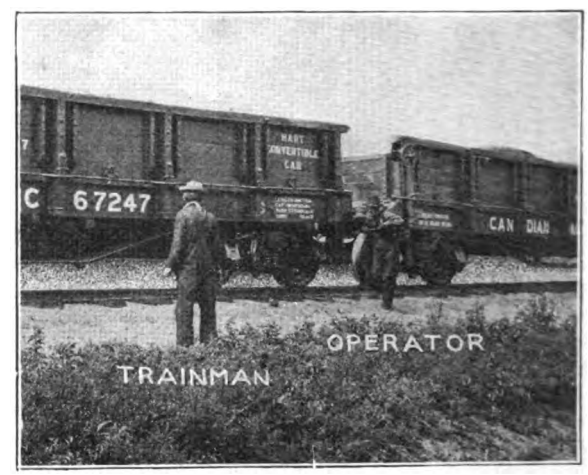


Center Dump Ballasting with Hart Cars. Ballast Evenly Spread with Plow Car.

On the busy tracks about cities it used to be common practice to shovel all the ballast from the car to the track to insure freedom from any delay whatsoever. In the congested multiple-track systems, where there is no chance to work at all upon the high-speed tracks, there were usually two alternatives: (1) to dump the ballast into an adjacent slow-speed track and then shovel it across, or (2) to shovel it directly from the car over into the high-speed track. Either was expensive in labor, and labor now comes on at a long price and goes off at the end of a short day.

The need of a car adapted to ballasting, which might also be used on occasion for commercial loading, had been felt for a long time. The Improved Hart Convertible Cars, which are adapted to center or side dumping and can also be used as a gondola car when desired, have been devised to meet the requirements stated. These cars are designed and patented, and are built by the Rodger Ballast Car Company, Chicago. The many improvements which have been added from time to time to afford greater ease of operation make the cars efficient not alone in maintenance work but in handling revenue traffic as well.

Maintenance officers are coming to recognize the definite economy in having an equipment of specially designed ballast cars, which may practically be confined to ballast service during the repair season, but which are capable of being transformed into open top revenue cars when occasion requires. By the assignment of ballast cars to maintenance use, a type of car is certain to be employed that is specially adapted to the rapid and efficient delivery of ballast to the track, and there is also a greater assurance that the ballast program will not be disrupted by a lack of cars. By far the larger percentage of the



Center Dump Ballasting with Hart Cars. Two Men Only Required to Unload the Cars.

roads in America have subscribed to this principle by making the Hart Convertible Cars standard for ballast service, and many roads in foreign countries also use them. It is estimated that at this time over 60,000 of these cars are in use. The center dump plan of unloading ballast, with the accompanying service of a ballast plow, was recognized as a labor-saving method by the Roadmasters' Association in convention in 1919.

Operation of Hart Cars

In operation the car next to the engine is dumped first and the hopper of each succeeding car is opened just before the preceding car is emptied, so that a normal flow will be running from it when the first car is finished. The operation is continued while the train moves evenly at a rate of about four miles an hour. As the cars are entirely self-cleaning no shoveling is necessary

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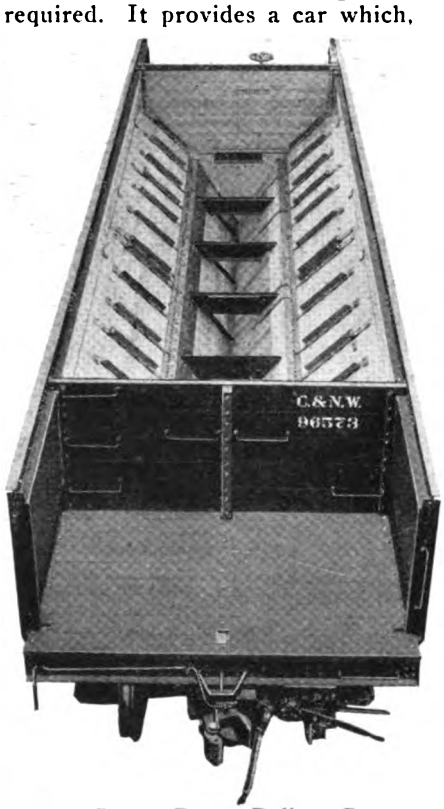
and in fact only one man is required for the operation of unloading. A performance of unloading a car a minute has been attained.

A Rodger Ballast Plow Car is located at the end remote from the engine and the plow is dropped by a second operator who keeps it down except when it has to be raised for crossings, frogs or switches. The ballast is cleaned from the track almost to the level of the top of tie if desired, and is banked evenly on each side, clear of the traffic. Adjustable extension wings enable the ballast to be spread several feet beyond the outer ends of the ties when preferred. The operation of plowing the ballast out leaves the track clear for trains, assuring that there will be no interruption to their movement.

The advantages of handling ballast by the Hart Convertible Cars are that the proper quantity is delivered and the burdensome, expensive operation of re-delivery of ballast is avoided. It is a means of conserving not only labor but material as well. The greater facility of making lifts of the track when the ballast is evenly distributed and plowed to the side is appreciated by all roadmasters and supervisors. If an exceptionally high raise is to be made and a second drag is necessary the ballast does not remain high within the track, to become a menace to employees working near by, or to passengers riding on the trains.

The Hart Ballast and Coal Car

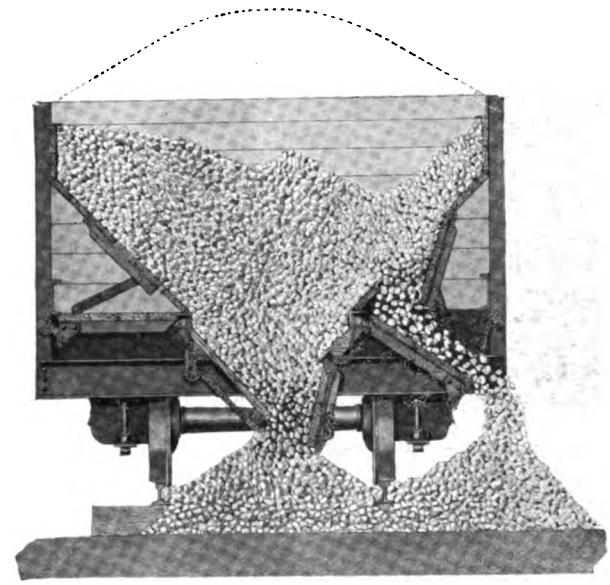
A special type of the Hart Convertible Car has been developed, which is known as the Hart Ballast and Coal Car. It is designed especially for use where unloading by a top plow is not required. It provides a car which, while still retaining the center dump features for ballast, may be converted quickly into a drop-bottom side-dump gondola for coal.



As a Center Dump Ballast Car.

In this car the vertical side doors are dispensed with, while the floor is provided with doors dropping away from the sides of the car, to provide openings for discharging a load of coal or other dumpable material when the car has been arranged as a gondola with bottom flat throughout its whole extent. When used as a ballast car the end gates are moved toward the center and the sections through this extent of the bottom are raised to complete the hopper.

There are special cases which make it desirable to drop ballast both into the center and to one or both sides of the track simultaneously, and a recent design of the Hart Ballast and Coal Car adapts it to this service. In reballasting one of a system of tracks excess ballast is usually desirable for making a shoulder on the one side, or alternately for filling between the tracks on the other. Also in the construction of additional main tracks, excess ballast must be provided on the outside of curves for the purpose of introducing the superelevation. The combination of both center and side dumping is of further use where spots recur which require a center


Hart Ballast and Coal Car. Center and Side Ballasting Simultaneously.

distribution, by reason of depressions in the grade having been surfaced out, while the ditch or shoulder requires a uniform filling throughout.

The Hart Ballast and Coal Car has been designed for conversion readily from a flat drop-bottom side dump gondola to a center and side dump hopper-bottom ballast car, dumping to the center and side at the same time if desired. The process of dumping through each of the three openings is within control of the operator at all times so that the exact amount may be delivered in every operation. When used as a gondola car the load is carried the full length of the car and it is thus suitable for general traffic uses.

The design through which the combination of center and side dumping is effected is such as to render the car strong and rigid in these operations. A door forms the greater portion of the upper part of the hopper on either side, as shown above, and swinging outwardly, opens the flow to one or both sides as desired; while the hopper is open or closed, dependent upon the need for center distribution or otherwise.

Improved Ballast and Work Car

The combination of a ballast and work car has many desirable features calculated to simplify the problems of ballasting and roadway maintenance. The Improved Hart Ballast and Work Car is designed to perform the

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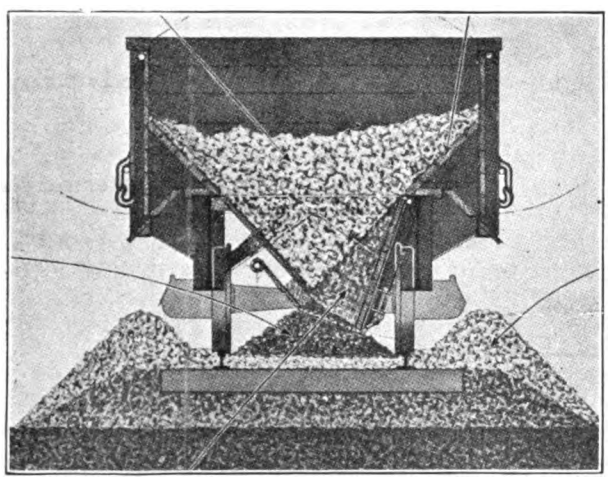
work of delivering ballast by the center or side dump methods, depositing the ballast to either or both sides at will, and of discharging all classes of materials to the side with the aid of a top plow. This car thus has the feature of being readily convertible from a center dump hopper ballast car to a flat bottom gondola car, with the side dumping feature adapting it to the service of delivering ballast for filling the center ditches or the plowing from the cars of other kinds of material in ditching or in new construction work.

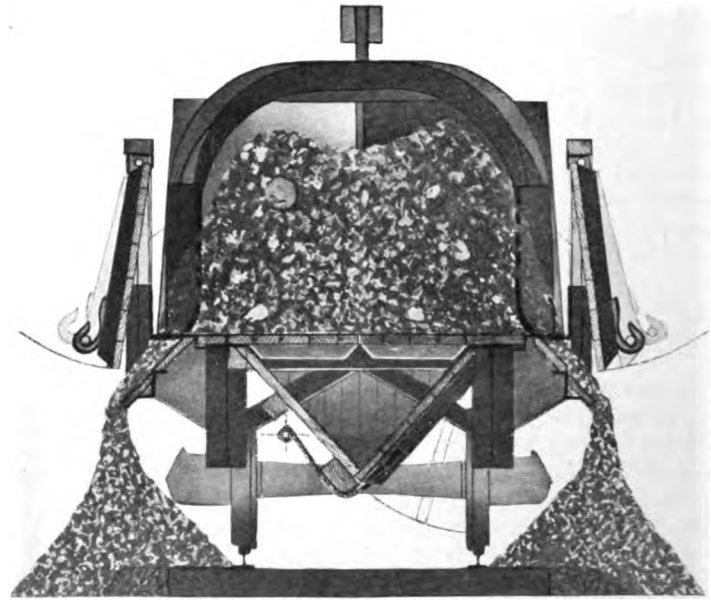
The floor of all the Improved Hart Convertible cars are so built that the middle quarters of the floor may be inclined to form a continuation of the sides of the permanent longitudinal hopper which occupies three-fourths of the linear extent of the car. Removable end gates complete the closing in of the hopper space thus provided. The hopper is designed to deposit the material in the center of the track, the operator having at all times full control over the flow of material from the hopper, so that it will not bury the rail. This is assured by the improved operating gear of the car which controls absolutely the opening of the door. The door of the hopper swings outward to open the pocket and is controlled by a special lever by which the extent of the opening may be regulated through a ratchet which works tooth by tooth over a range of from 4 to 15 teeth. As the levers which open and close the door are a part of



Improved Hart Convertible Car. Ballasting Center Dump.

the car no time is lost in searching for a car wrench, and the danger of personal injury is entirely eliminated. The skill necessary to make an even distribution of ballast is acquired by a very little practice.

In the Improved Hart Convertible Car when used as a side dump car, the horizontal floor of the car is made somewhat less in width than the distance between the sides, this detail being adjusted to the preference of the individual road, and from the extreme edge of this level floor the remainder slopes down to a point beyond the doors, which are lengthened accordingly. This increases the door opening area and material, when displaced by the plow, falls by gravity as soon as it reaches the outer edge of the floor, being discharged clear of the rails. This provision removes the strain on the dumping side of

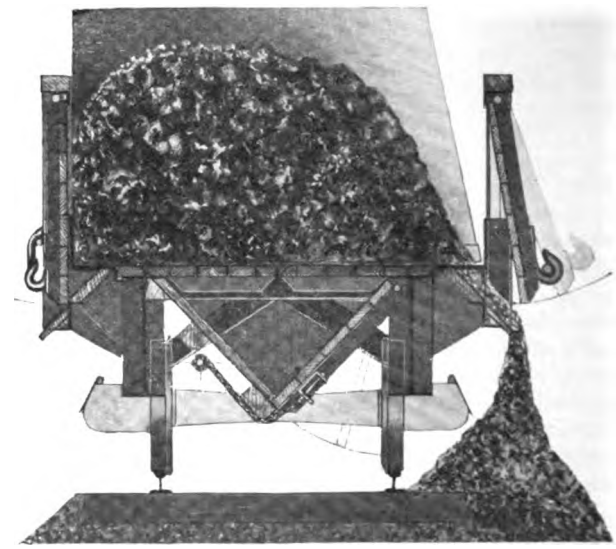


Unloading with Top Plow to Both Sides.

the car and also reduces that on the opposite side.

The sides of the car consist of doors each one-third the length of the car, which reduces the number of full-length stakes to four on each side, the intermediate stakes being shortened to the least height necessary for serving as guides for the plow. This reduces by one-half the obstruction to the plowing off of material. The long stakes are made of great strength and will carry the side with entire safety because of the relief afforded the doors through the sloping floor edges.

The side door shaft is placed on the door instead of the underframe, which not only prevents any



Unloading with Top Plow to One Side.

chance of damage by falling material but avoids clogging it, so that it always remains operative. The shaft is a straight bar and is strong enough to hold the doors tight under all conditions of loading and

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unloading. The shaft makes it possible to discharge on one side while the other is closed. As the side shaft lock is operated from the end of the car it can be opened or closed on trestles while the train is moving.

A feature of the improved car is the plow guides. The plow is carried from car to car on an apron and is guided into the car by the curved corner stakes. The plow rides on metal surfaces along the outer edges of the horizontal floor which extends to, and upward for the full distance along the side stakes, this feature saving wear on the floor and serving to keep the plow flat on the floor. Its action also becomes more positive in plowing off the ballast which might lodge in the runway or be ground into the floor. The Hart car thus may be plowed clean and the loss from carrying back to the quarry or gravel pit of a quantity of material is avoided.

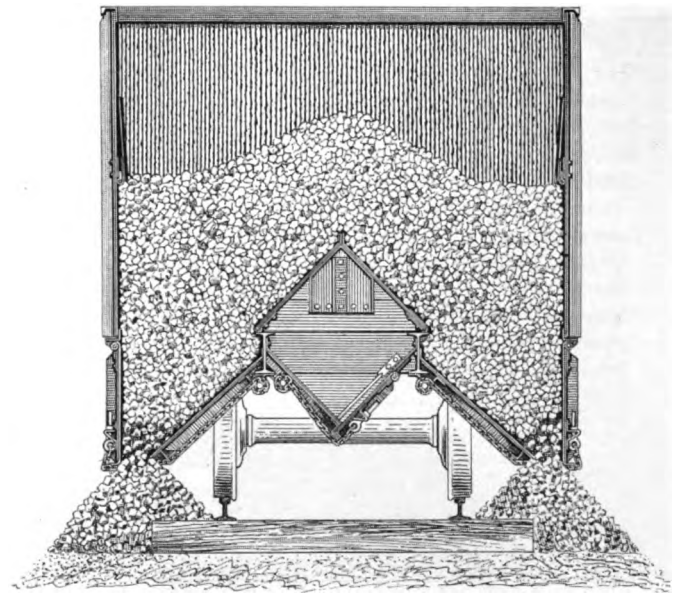
It is recognized that cars are subjected to extremely heavy strains in side dump work owing to the character of the materials necessarily used for filling purposes. Unless the car is rigidly constructed these are apt to cause the laying up of the car for repairs, which sometimes entails transfer of the material. In the Hart Convertible Cars the requirements of strength and rigidity have been given special study and the dependable service of these

Unloading Dirt with a Top Plow

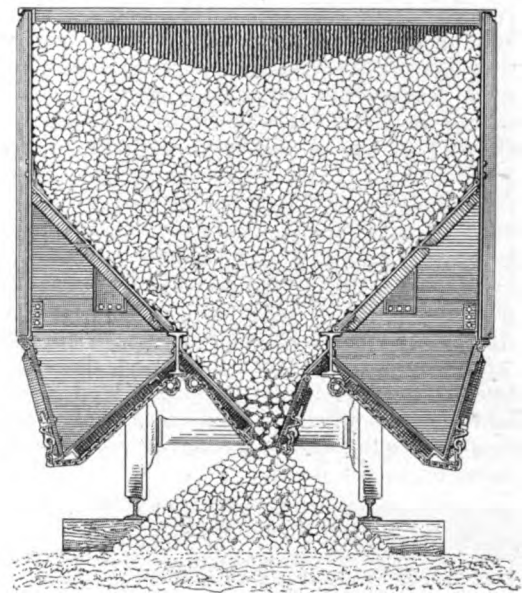
cars has been established. A safety feature is the extent of the platform at each end whereby ample room is afforded for men to ride, and the danger from their riding on the loads is obviated.

Hart Hopper Ballast and Coal Car

In certain ballasting operations, and in revenue coal traffic, the demand is presented for a car which will dump continuously to the center or to the sides, and these two functions are provided for in the Hart Hopper Ballast and Coal Car. When used for side dumping a rectangular space is formed lengthwise of the car, of which the hopper bottom forms the lower half and a peaked cover, made up of two strongly constructed doors, the upper half. In this position the ballast or coal may be discharged to the side by rotating the doors which form the lower portion of the sides of the car. When used for center dumping the two sections forming the top of the unused space are rotated through 90 deg. to form the continuation of the sides of the hopper. The Hart Hopper Ballast and Coal Car is entirely self-cleaning in either operation. In both positions the doors rest on diaphragms, which give the interior construction ample rigidity.



Hart Hopper Ballast and Coal Car, Side Dumping



Hart Hopper Ballast and Coal Car, Center Dumping

The Rodger Ballast Car Company, manufacturers of the Hart Convertible Cars, has its office in the Railway Exchange Building, Chicago. It maintains an engineering department to design cars for special requirements, based upon the general convertible features of the typical cars. Over 70,000 of these cars are in use on practically all the larger railway systems, and on most of the smaller ones in America, where they are doing duty as time and labor savers.

RODGER BALLAST CAR COMPANY, CHICAGO

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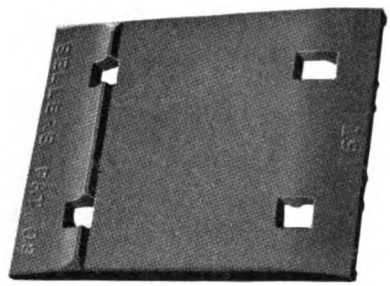
General

Tie plates have three purposes; first, reduction of the volume of tie renewals and the consequent cutting of material and labor costs; second, reduction of maintenance labor costs for regauging and holding alignment of track; third, increased safety through the elimination of spreading rails under traffic. They are now recognized as a most important accessory to good track, and so necessary that it has become the ultimate aim of every maintenance engineer to have two plates on every tie in his track. The expenditures for tie plates in the present standards of some of the railroads will reach 15 per cent of the cost of all materials in track above the ballast including the ties. During the past twenty years as tie plate expenditures steadily mounted in volume, engineers have given much



Sellers Tie Plate—Top View

study to tie plate design, and have experimented with many varied types; and in stressing the function of gage-holding it was found that the primary purpose was often being disregarded and many types being used were accelerating instead of retarding the destruction of the ties. It was finally very generally agreed that to attain a maximum of holding power with a minimum of damage to the tie, the bottom design of a tie plate should consist of a series of transverse or diagonal shallow ribs, dull-edged, to permit of seating on the tie by compression, instead of by cutting the top fibres of the wood, and the great preponderance of tie plates are now so made. With the matter of tie protection settled, engineers have been free to turn their attention to securing the utmost durability in the tie plates themselves, to the elimination of breakage, the reduction of buckling to a minimum, the arresting of crystallization and corrosion in the metal.

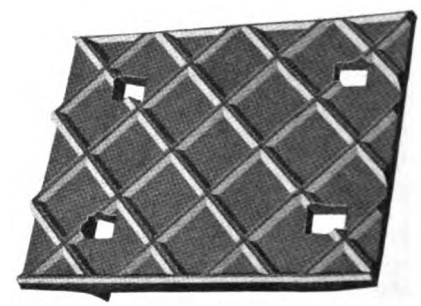
Sellers Anchor Bottom Tie Plate

In the Sellers Anchor Bottom Wrought Iron Tie Plate, the Sellers Manufacturing Co. offers a tie plate which meets all requirements — maximum protection to the tie, absolute gage holding, greatest possible durability of material and design. This company operates its own mills and for the past fifteen years has devoted its capacity exclusively to the manufacture of this one design of tie plate. That its tie plates have met with favor is indicated by the fact that over 150,000,000 are in track on more than 300 American Railroads.

A distinctive feature of the Sellers Anchor Bottom Tie Plate is the construction of the bottom, which consists, within a box pattern, of two sets of ribs extending diagonally across the plate in opposite directions, forming a diamond shaped grid. These ribs are $\frac{5}{32}$ in. deep, dull edged, and seat themselves into the top fibres of the tie by compression, without cutting. The diagonal arrangement acts as a clamp in arresting season checks in the tie and prevents shifting and lateral motion and the attendant abrasion of the top fibres of the tie. By actual test it has the gage holding power of two spikes driven home, and through its truss effect increases the strength of the tie plate against buckling by up to 10 per cent. It lends itself to ready application to new or old and hard or soft ties, and the plate can easily be regaged when the wear on the rail makes realigning necessary.

These tie plates are rolled from wrought iron by the end-over-end method, which places the fibre of the iron at right angles to the shoulder, and to the stresses of traffic when in track, a positive guarantee against breakage. Since it perfected this method of rolling in 1908, this company has never found or had brought to its attention a Sellers plate which had broken in track. Wrought iron does not crystallize under the shock of traffic, and as is well known has marked resistance to corrosion from climatic conditions, brine drippings, sulphuric acid gases in tunnels, etc. Sellers plates under service tests have shown only one-third the loss found in steel plates. This company claims that its tie plates have at least twice the life of steel, and boasts that none of them have yet been scrapped on railroads where they have been used continuously and exclusively for twelve years.

Sellers Anchor Bottom Wrought Iron Tie Plates are made in a great variety of sizes, with or without



Sellers Tie Plate—Bottom View

taper for canting the rail, and with or without cambered top. Large quantities are carried in stock for quick deliveries.

The headquarters and mills of the Sellers Manufacturing Company are located in Chicago and its eastern sales office at 50 Church Street, New York.

It is also represented by the following agencies:

Sellers Anchor Bottom Tie Plate Co. of Canada, Ltd.	Montreal, Quebec
W. L. Jefferies, Jr.	Richmond, Va.
John F. Glenn & Co.	Atlanta, Ga.
B. W. Parsons Co.	St. Paul, Minn.
W. D. Jenkins	Dallas, Texas
W. D. Jenkins	Houston, Texas
Jas. C. Dolan	Denver, Colo.
Eccles & Smith Co.	San Francisco, Cal.
Eccles & Smith Co.	Los Angeles, Cal.
H. M. Fetterolf	Philadelphia, Pa.

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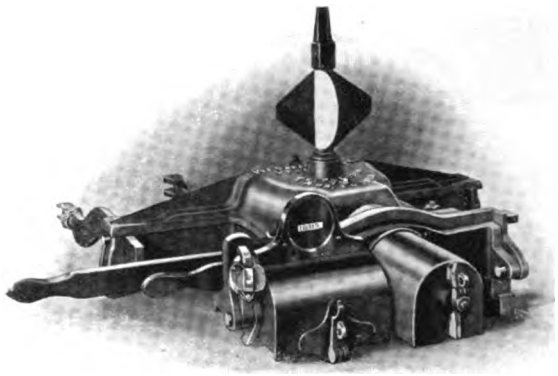
General

The Signal Accessories Corporation, Utica, N. Y., as may be implied from its name, specializes in the development of accessories used in connection with signals. These include the Triplelock Switch Machines, the Bossert Switch Point Adjusters, Directional Track Contractors, Steel Enameled Signal and Dwarf Blades, Number Plates, Carley Wire Terminals, Lightning Arresters, Adjustable Lamp Blocks, Bootleg Terminals and Anchors, Pipe Carrier Supports, Foundation Extensions, Adjustable Rail Braces, Saco Screw Locks, Expansion Shells, Plunger Lock Stands, Roundel Protectors, Universal Machines, Friction and Rubber Tape, and Concrete Battery Boxes.

Triplelock Switch Machines

The protection of non-interlocked facing point switches in main tracks, particularly in automatic signal territory, requires an appliance which is effective and dependable under all conditions of service. The Triplelock Switch Machine was designed primarily to accomplish at a single switch the same function that an interlocking plant does at a group of switches.

This device operates either a mechanical or electrical signal and, when desired, is equipped with an

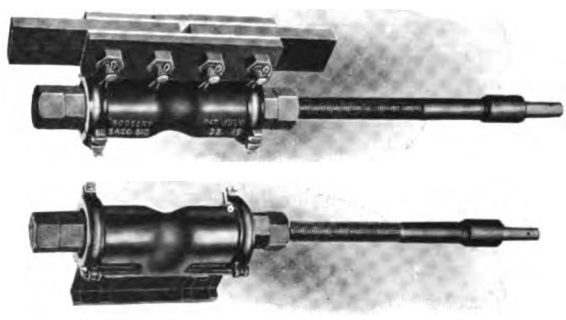


Triple Lock Switch Machines

electric switch lock having a visual indication. and with either a four or ten point circuit controller. Machines can be furnished either low or seven foot target, two or three levers.

Switch-Point Adjusters

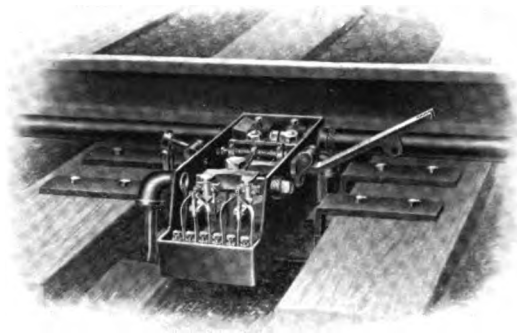
Switch point adjusters serve the purpose of providing the adjustment necessary for the proper functioning of switches. The Bossert Switch Point Adjusters were designed to overcome the trouble experienced with the open type of adjusters when dirt, stones, snow or ice clog the moving parts and interfere with the proper operation of switches, while creeping of rails does not effect its working. Two principal styles are manufactured, style No. 2B and No. 2B-E. The first is principally used for non-insulated, while the second is adapted for insulated work.



Switch Point Adjusters

Fusticlo Directional Track Contactor

This device has been developed by a prominent Signal Engineer to meet the demand for a reliable track instrument for automatically controlling highway crossing signals, annunciators, etc. It will positively make or break circuits in accordance with the direction in which the train passes over it. It has proven satisfactory under

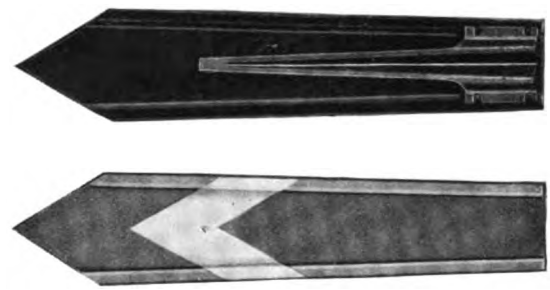


Fusticlo Directional Track Contactor

all conditions of service, which includes heavy yard service, severe winter weather, heavy sleet storms, bad track conditions, etc.

Saco Enameled Steel Signal Blades

These blades serve the purpose of giving a clear, visual indication to the engineer, since no part of face of blade is hidden by clamps or bolts, on which account many railroads use a shorter blade. Non-fading porcelain enamel insures a constant bright indication to enginemen. Strain on enamel is well distributed.



Saco Enameled Steel Signal Blades

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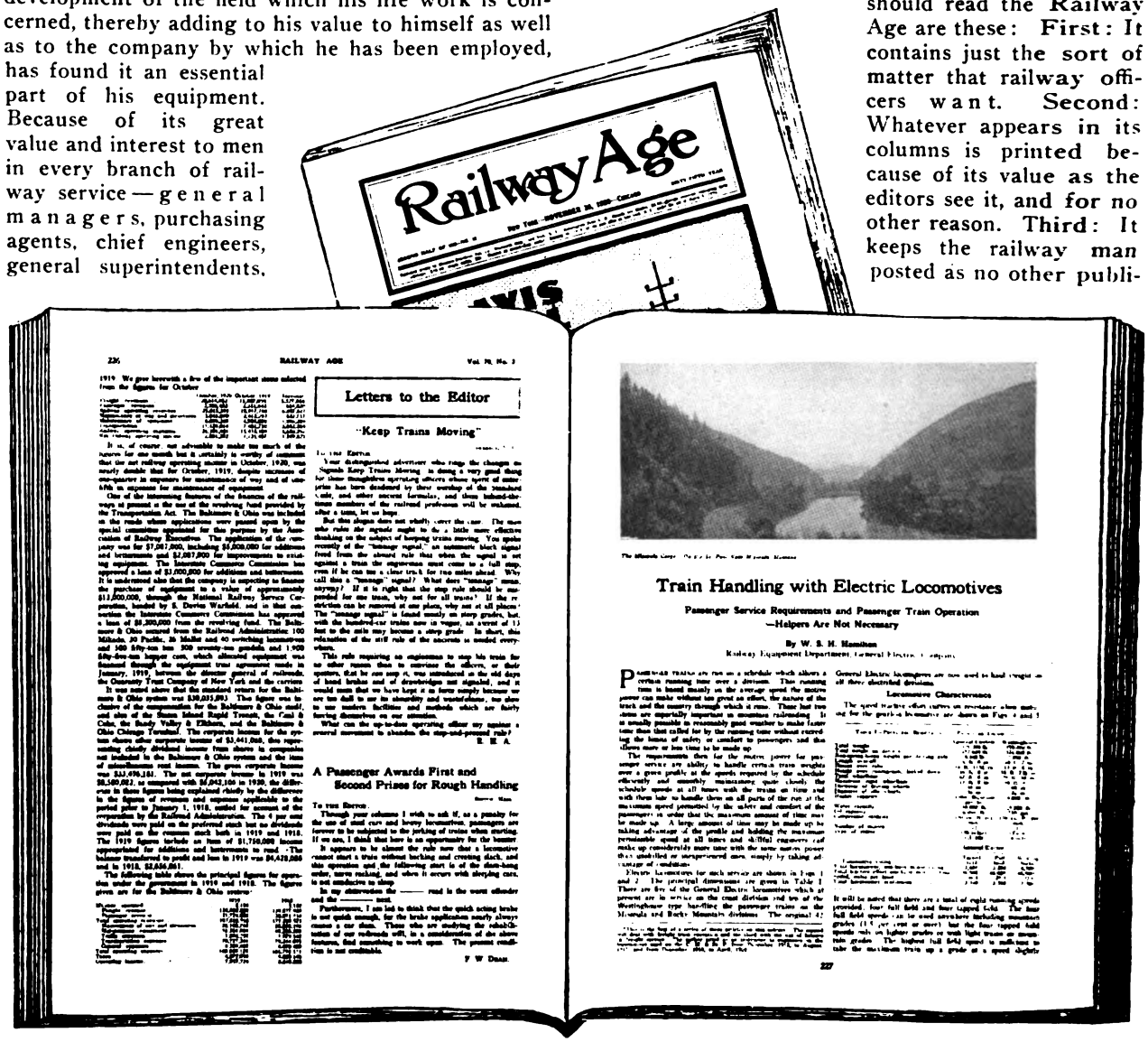
Who Reads It

For more than sixty years the Railway Age has been the forum for the consideration of such railway problems as were still open to discussion, as well as the storehouse of such facts as should from week to week and from year to year be added to the chronicle which makes up railway history. For these reasons the officer or employee seeking to keep himself informed of the development of the field which his life work is concerned, thereby adding to his value to himself as well as to the company by which he has been employed, has found it an essential part of his equipment. Because of its great value and interest to men in every branch of railway service—general managers, purchasing agents, chief engineers, general superintendents, and maintenance engineers, as well as all those in subordinate positions who aspire to rise—its publicity value in relation to devices which appeal to such officials is equally great.



Why They Read It

The executive officers of the railways read the Railway Age because they know they find in it that which they need concerning matters of operation, relations of carriers to the public, finance and accounting, traffic, engineering and maintenance, motive power and rolling stock, signaling, foreign railways, railway supplies, and those subjects which are of greatest importance to them in their work. Because it covers the entire field of railway work largely from the operating standpoint, and because, due to the fact that for sixty-six years it has been doing it, they know the Railway Age possesses both the intent and the power to serve busy railway officials each week with the worth-while facts and data so necessary to them. That is why railway officers read the Railway Age and why every railway man who strives for advancement should also read it.

The reasons why every progressive railway man should read the Railway Age are these: First: It contains just the sort of matter that railway officers want. Second: Whatever appears in its columns is printed because of its value as the editors see it, and for no other reason. Third: It keeps the railway man posted as no other publication can, regardless of the office or the employment he holds. Fourth: The desire on the part of an officer or employee to see the "Age" is always an indication to his superior officers that that man is coming on.

This, then, in brief, is what the Railway Age brings to and accomplishes for its readers week after week, year after year, at an expense slight indeed when compared to the aid it renders to those thousands of railway men who look to and rely upon this publication not alone as a part of their working equipment, but as an indispensable part of their foundation upon which to build for advancement.

Subscription: United States, Canada and Mexico, $8.00 a year; foreign countries, $10.00 a year.

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A Working Tool for Maintenance Department Men

The Railway Maintenance Engineer, published monthly, is devoted exclusively to railway maintenance department matters. It presents each month to its readers information of value to all engaged in the upkeep and improvement of the track, structures, and other fixed physical properties of railways. Its aim is to assist in the dissemination of information on up-to-date maintenance of way work, and thus to aid all employees of that department, whether chief engineers or section foremen, in handling their work more economically and efficiently, while affording the latter an opportunity to secure a greater knowledge which will be of service to them in securing advancement.

This is the reason practical railway men, whether engineers or not, find the Railway Maintenance Engineer of real value. Assistant engineers find in its pages discussions of questions and descriptions of practice that are of real value to them in solving the problems incident to their position and in enabling them to look forward hopefully toward the higher positions of the service. Roadmasters and foremen by its use find themselves more capable of interpreting the reasons underlying instructions that have been given them and consequently are enabled to render more and better, because more intelligent, service to the company employing them. And by this educational process the increase of their value to the company means a corresponding or greater increase of value to themselves.

Engineers and superintendents who have to deal with maintenance of way problems, supervisors of bridges and buildings, of water service and track, and the foremen and employees of every department on the right of way, find in every number of the Railway Maintenance Engineer some helpful suggestions to aid them in their daily work and increase the value of their services to their company, and thereby improve their own conditions, as employees. No one man's knowledge or experience is sufficient to enable him under all the changing conditions of track maintenance, and the allied services, to grasp at once the best solution of a difficult problem. Some other man engaged in similar work has met the same difficulty and disposed of it successfully. The Railway Maintenance Engineer is the clearing house of ideas and experiences in all classes of maintenance work.

The Railway Maintenance Engineer aims to cover and does cover from month to month the features of maintenance work that are uppermost in the minds of the men who read it. It does this by affording a field for the interchange of ideas and experiences developed among the thousands of thinking men in the maintenance departments of American railways.

The subscription price in the United States, Canada and Mexico is $3.00 a year; in foreign countries, $5.00.

SIMMONS-BOARDMAN PUBLISHING COMPANY, NEW YORK, N. Y.

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General

The Railway Signal Engineer, published monthly, enjoys the distinction of being the only paper of its kind in existence. It is a tool designed especially for the use of those railway officials and their subordinates who must know how signals are made, erected, operated and maintained. To signal engineers and signal supervisors, maintainers, batterymen, machinists, draftsmen, towermen, lampmen and all others who have to do with the installation and maintenance of railway signals, the Railway Signal Engineer has proved a guide in which these men place the utmost confidence.

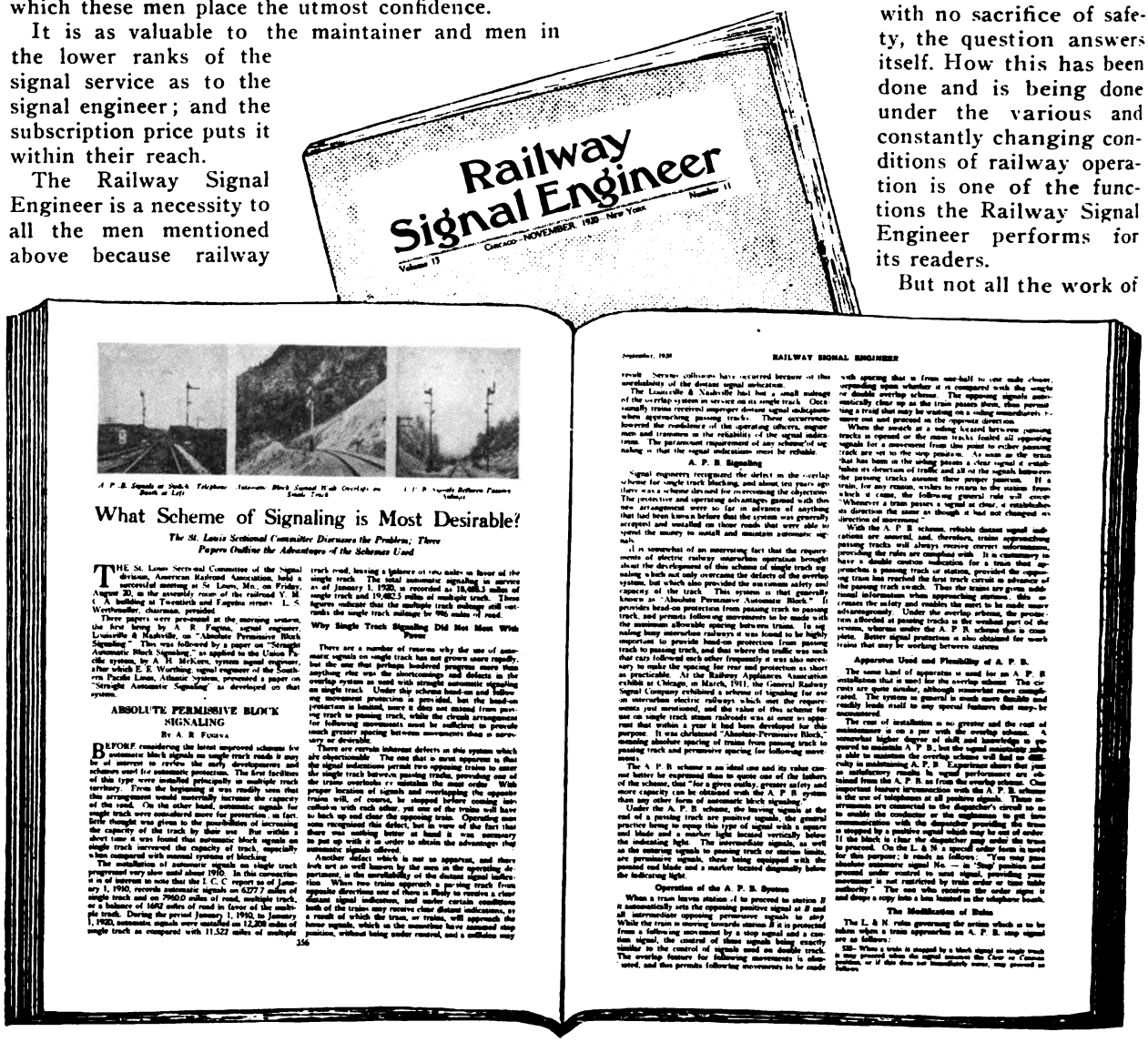
It is as valuable to the maintainer and men in the lower ranks of the signal service as to the signal engineer; and the subscription price puts it within their reach.

The Railway Signal Engineer is a necessity to all the men mentioned above because railway signaling is a highly technical art. Because the art of railway signaling is developing rapidly and the best literature of the subject is based on the knowledge that experience and study are adding, from day to day, the very basis of the articles placed before you each month in the Railway Signal Engineer. Books will not give all of the more recent developments, but the reader will find them in this working tool of the signal man which serves to preserve the experiences and ideas of practical signal men as they are encountered and as they are worked out because of difficulties that are immediately faced and must be worked out.

The original purpose of signaling systems and signal apparatus was confined solely to considerations of safety. Probably that may be counted its chief function now; but if this purpose can be fulfilled and at the same time greater economy and expedition of freight movement secured, the application of the art serves a double purpose. Perhaps this thought is best crystallized in the slogan adopted by several of the principal manufacturers of signal apparatus —"Why stop a moving train to instruct it to proceed?" If this continuous movement can be secured with no sacrifice of safety, the question answers itself. How this has been done and is being done under the various and constantly changing conditions of railway operation is one of the functions the Railway Signal Engineer performs for its readers.

But not all the work of a railway signal department is technical. The principles that are developed by the engineer must be put in practice and the apparatus for their application maintained by practical men. Their requirements, new "Kinks" for the effective and economical performance of their work, are as much a part of the field of the Railway Signal Engineer as are the developments of the principles of the art and the perfection of the necessary mechanical apparatus.

Subscription in the United States, Canada and Mexico, $3.00 a year; in foreign countries, $5.00.



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How It Serves

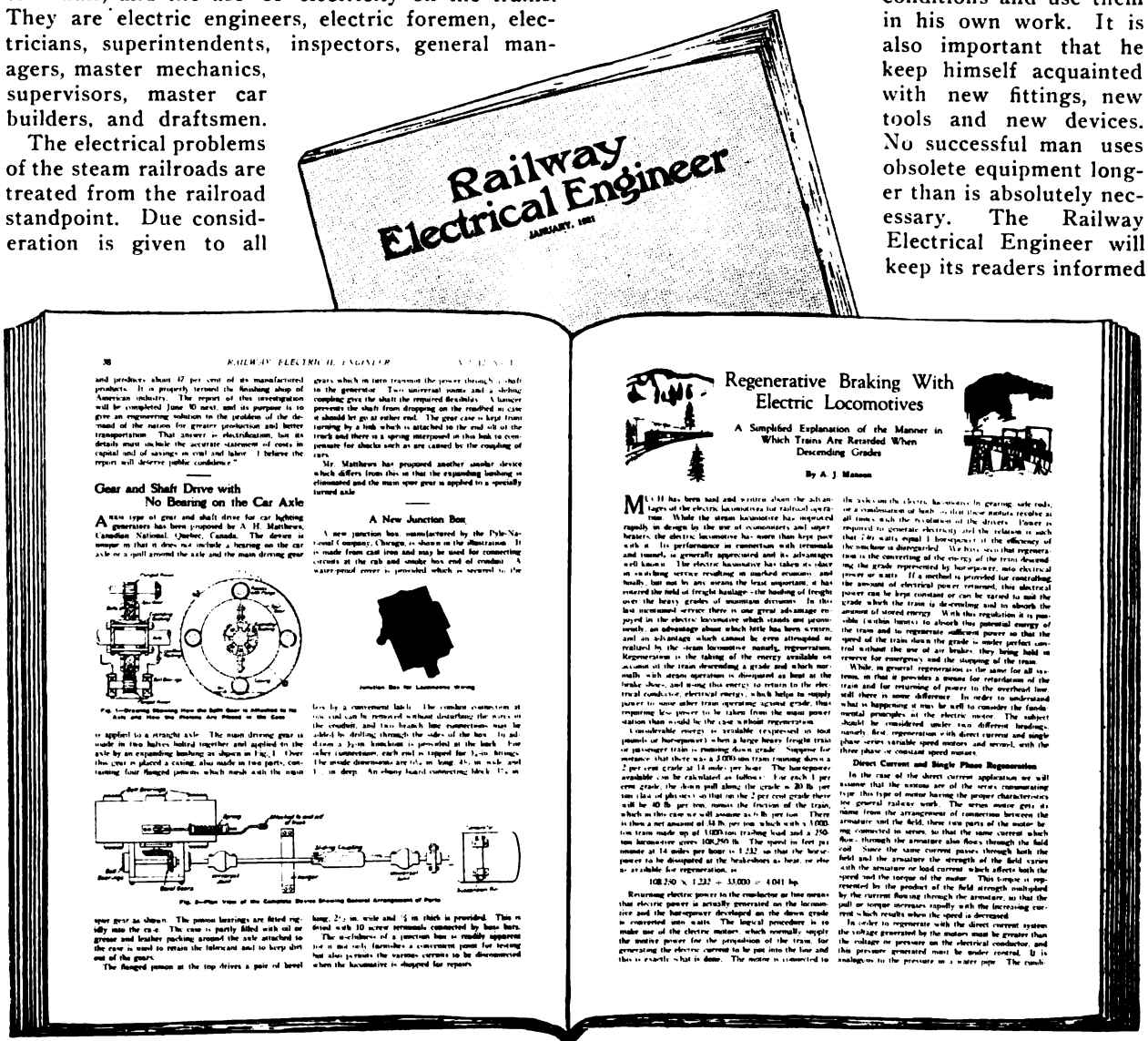
The men who read the Railway Electrical Engineer are those who are doing electrical work in the steam railroad field, and those who are responsible for having the work done. This includes railroadmen in all positions who are interested in heavy electric traction, electric arc welding, electric power and light for shops, yards and terminals, and the use of electricity on the trains. They are electric engineers, electric foremen, electricians, superintendents, inspectors, general managers, master mechanics, supervisors, master car builders, and draftsmen.

The electrical problems of the steam railroads are treated from the railroad standpoint. Due consideration is given to all other railroad functions when discussing electrical problems—that is, the problem is not only electrical, but its solution must fit in with all other phases of railroad operation without upsetting established methods and practices which concern apparatus other than electrical. This is a phase that most electrical magazines do not cover. In other words the electrical engineer on a steam railroad must be first of all a railroad man and this publication takes up his problem from his point of view. Electrical developments are emphasized from time to time as their importance to steam railroad operation becomes apparent. Reviews of successful electrical installations on other roads are presented.

The Railway Electrical Engineer is also a medium for the interchange of ideas on practical subjects pertaining to electrical work on steam roads.

Why You Should Read It

Men engaged in railway electrical work read the Railway Electrical Engineer because it tells month after month how others are doing similar kinds of work. The reader can take those ideas which are best suited to his own conditions and use them in his own work. It is also important that he keep himself acquainted with new fittings, new tools and new devices. No successful man uses obsolete equipment longer than is absolutely necessary. The Railway Electrical Engineer will keep its readers informed of new devices as they come out. Furthermore, it affords them a medium for the exchange of ideas.



What It Costs

After a man has been a subscriber for one year he has no difficulty in recalling one or more instances in which something he found in the Railway Electrical Engineer saved him a number of hours of time, saved him the need of buying expensive equipment or helped him to make a real job of the work he was doing. The same man will testify that the advantage gained much more than offset the actual cost of a subscription. Therefore the cost is nominal.

Subscription: United States, Canada and Mexico, $3.00 a year. Foreign countries, $5.00 a year.

SIMMONS-BOARDMAN PUBLISHING COMPANY, NEW YORK, N. Y.

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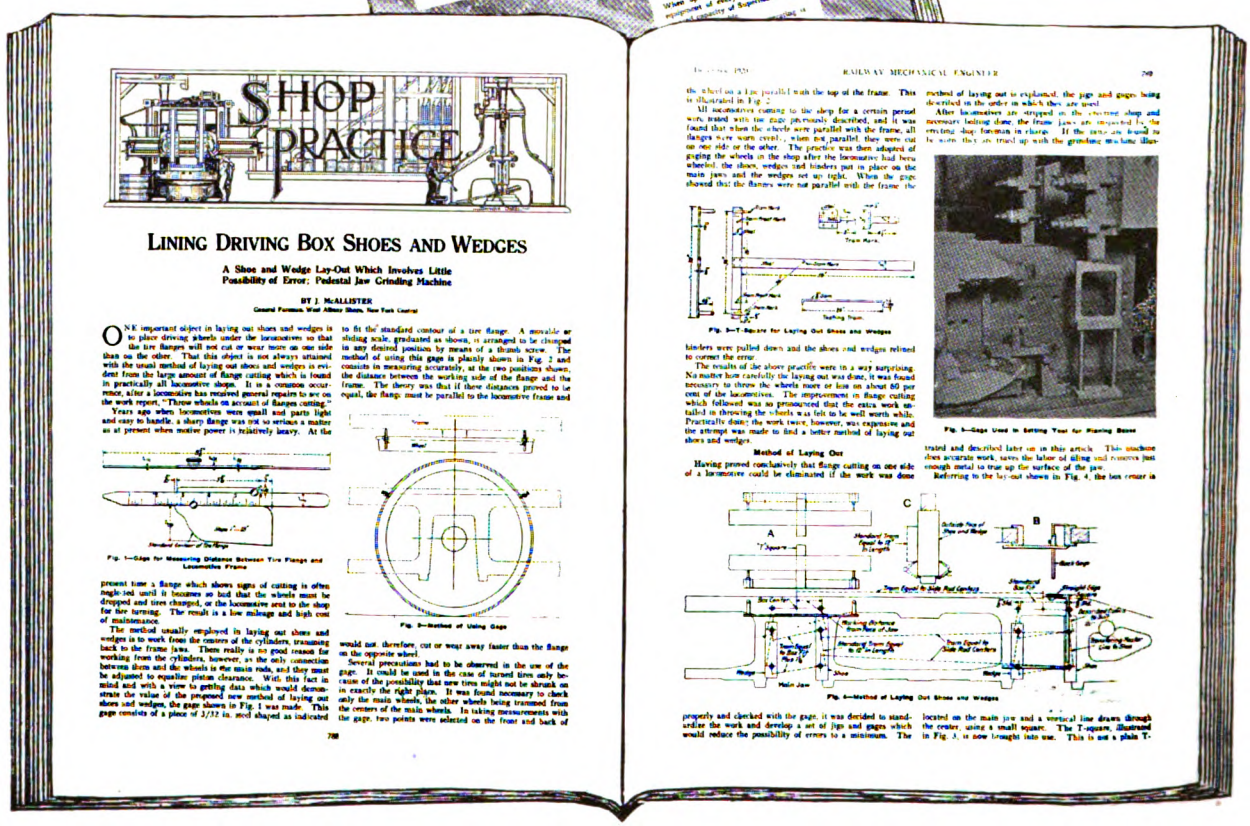
88 Years of Service to the Railways

The Railway Mechanical Engineer, then The American Railroad Journal, was established in 1832. Upon this fact it bases its claim of being the oldest technical paper in the world. It specializes on railway mechanical department problems, railway shop equipment, and railway shop problems.

Since its inception no effort has been spared to inform its readers of the latest practices and developments in the railway mechanical field, and that success has been attained is fully attested by its popularity today, not only in America, but in practically every foreign country, where it is held in very high esteem.

The purpose of the Railway Mechanical Engineer is to keep its readers



—the energetic men in the mechanical departments of railways—informed of the latest developments, both in theory and practice, in car and locomotive design and maintenance and shop operation. It aims to act as a clearing house of ideas for the benefit of its readers. Its editorial staff is not only made up of the men who are accredited as the editors, but a vast number of public-spirited, open-minded, energetic railroad men are always willing for the benefit of their fellowmen to tell in the pages of the Railway Mechanical Engineer of their experiences and the lessons they have learned.

To those who are anxious to improve their condition and to perfect their practices, the Railway Mechanical Engineer will be invaluable. It is a well-known fact that wherever improvements are sought the experience of others engaged in similar work is first determined. The Railway Mechanical Engineer provides this. It has led, and will lead in the future, to many changes in design, methods and organization, and improved practices, etc. Particularly at this time is it necessary for the mechanical man to obtain this paper on account of the radical changes and developments being made in all departments of railroading. It affords a method by which a railway mechanical department man may with but nominal expense keep in touch with the latest developments and up-to-date practices. As an investment, it cannot be overlooked.

Subscription, $4.00 per year in the United States, Canada and Mexico; foreign countries, $5.00.

The Boiler Maker

The Boiler Maker is a monthly publication devoted to the design, construction and maintenance of boilers, whether railway, contract or marine. For eighteen years it has been recognized as authority on these subjects, and by its publication of new developments in design and construction and suggestions as to improvements in maintenance, it has helped to make boiler history as it has chronicled it.

Subscription, United States, Canada and Mexico, $3.00; foreign countries, $5.00.

SIMMONS-BOARDMAN PUBLISHING COMPANY, NEW YORK, N. Y.

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General

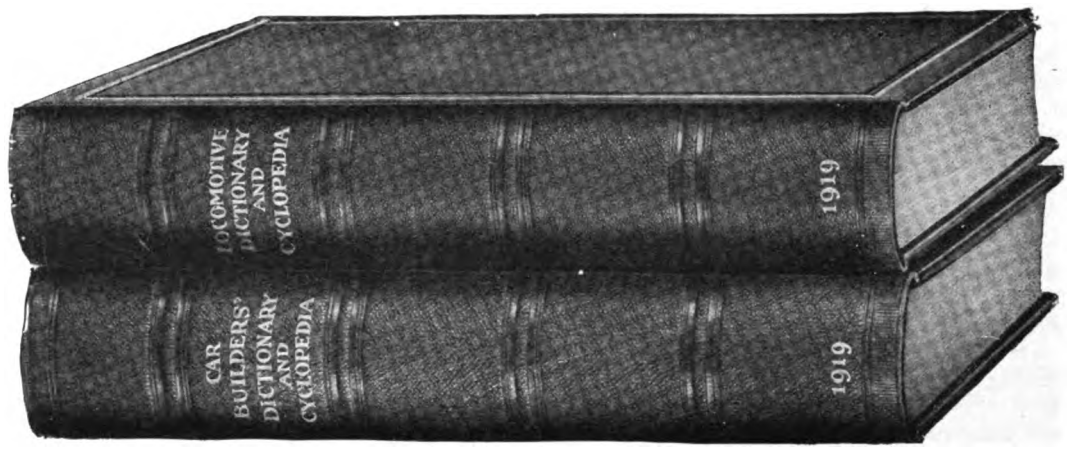
The Simmons-Boardman Publishing Company, Woolworth Bldg., New York City, has for many years published the Car Builders' Dictionary and Cyclopedia and the Locomotive Dictionary and Cyclopedia. Each volume is made up of condensed information concerning the latest mechanical appliances for the safe, efficient and economical operation of motive power and rolling stock, with complete details of construction and methods of operation. They are of every day use and value and indispensable to the designer, the engineer, the mechanic, the repairman and to the purchaser of supplies for either the motive power or rolling stock department. They are also almost equally valuable to the officer or employee of the engineering or maintenance of way department, because of the close operative connection existing between the physical structures with which he has to deal and the motive power and rolling stock forming another part of the same transportation unit.

Locomotive Dictionary and Cyclopedia

The Locomotive Dictionary and Cyclopedia was compiled and edited for the American Railway Master Mechanics' Association by Roy V. Wright, Managing Editor of the Railway Age, and Editor of the Railway Mechanical Engineer, and Frank H. Sauter, Associate Editor, under the supervision of a committee appointed by the American Railway Master Mechanics' Association.

The Locomotive Dictionary and Cyclopedia is maintenance. It is a book of 1334 pages, copiously illustrated throughout. The three sections of which it is composed are made up as follows: Definitions, 248 pages; Illustrated Section, 870 pages, 3071 illustrations; and Catalog Section, 204 pages, to which is added a Directory of Products and Index. The work is of constant usefulness to car builders, manufacturers and all who are engaged in the design, construction or use of cars or their appliances.

Price, cloth binding, $10; leather binding, $15.



Car Builders' Dictionary and Cyclopedia

The Car Builders' Dictionary and Cyclopedia was compiled and edited for the Master Car Builders' Association by Roy V. Wright, Managing Editor of the Railway Age and Editor of the Railway Mechanical Engineer, and Charles N. Winter, Associate Editor, under the supervision of a committee appointed by the Master Car Builders' Association.

The Car Builders' Dictionary and Cyclopedia is the only work of its kind published. It is an illustrated vocabulary of terms, designating American railway cars of all classes, their parts, attachments and details of construction. It is authoritative and complete, and has not only become a standard work and reference book in America, but has been increasingly valuable to railway men in all countries who are in charge of the design and maintenance of car equipment.

The Car Builders' Dictionary and Cyclopedia is an authoritative work on all points of car design and the only work of its kind published, and because it is authoritative and complete in definitions and illustrations of American locomotives, their parts and equipment, together with typical illustrations of machine tools and devices used in their maintenance and repair, it has not only become a standard work and reference book in America, but has become increasingly valuable to railway men in all countries who are charged with designing and maintenance of locomotives.

This work has become a book of standard reference in the motive power field and is used in all countries by the men who are charged with the design and maintenance of locomotives. It is divided into three sections: Definitions, Illustrated Section, and Catalog Section. It contains 1284 pages, over 3000 illustrations, and is full of valuable and interesting data on the latest developments in its field. Its field of usefulness extends also to those who have to do with the physical structures necessary to locomotive operation.

Price, cloth binding, $10; leather binding, $15.

SIMMONS-BOARDMAN PUBLISHING COMPANY, NEW YORK, N. Y.

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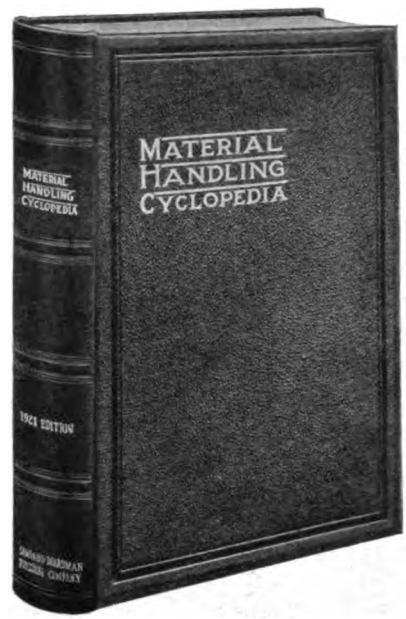
MATERIAL HANDLING CYCLOPEDIA

Machines and Materials

Produced by the same publishers who compiled, edited and issued the Maintenance Cyclopedia, the 1921 Material Handling Cyclopedia carries weight. The same engineering accuracy which characterizes the Simmons-Boardman railway publications has been attained in this new volume of over 800 pages. Material Handling Cyclopedia covers the principles of mechanical handling. It illustrates methods and systems that can be applied to the very problems that come up in the office every day. For instance, in one chapter of the book, devoted to handling systems, is a complete treatise on freight handling, not alone at railroad terminals but at docks and piers and in warehouses. Wherever material is moved there is need for this new book. Every man on the editorial staff of the Material Handling Cyclopedia is qualified for his work by a broad background of experience. The combined periods which these editors have spent in their respective fields amount to one hundred and fifty-one years. This century and a half of experience is made available to everyone qualified to use it through the Material Handling Cyclopedia.



As an example of the thoroughness which has characterized every step of the work on this essential text, in connection with the conveyor section of the book, a member of the staff has examined every patent on conveyor construction issued in the last twenty years. Every important detail has been considered in making the text complete. The book is a job worth doing—and from cover to cover it has been done well. More than six hundred and fifty pages of answers to problems of material moving will be included in the editorial section of this text. Supplemented by photographs and drawings, the application section will point out advantages of methods and systems which have passed the test of service.

Materials Covered

Effective short cuts in moving materials are brought out in the pages of Material Handling Cyclopedia through clear descriptions, simple diagrams and action photographs. Some of the materials on which useful handling data are given are sand, gravel, coal, ore, ashes, trap rock, brick, cement, boxes, barrels, steel containers, scrap iron, rails, ties. For the user's convenience the book is divided into three main sections. The first of these is the Definition Section, in which hundreds of materal handling terms are defined. In the application section of the text the best practice in the use of transferation machinery is described and illustrated. The third division, the Catalog Section, is equally valuable, for it gives much data on sizes, capacities, and operating characteristics of particular makes of machines.

Founded on Solid Facts

Back in the days when the Material Handling Cyclopedia was little more than an idea, the men whose job it was to make it a useful reality got together. Every one of these men had a background of experience in some branch of material handling engineering. One editor, for example, had been terminal engineer for a prominent railroad for many years. Each of them was trained in publishing. Yet they felt the need of the sort of information that would knit together the different branches of machine application which constitute the Material Handling Field as a whole.

The Research Department was established. Men went out into freight terminals, coal mines, metal mines, marine terminals, and on construction jobs. They studied at first hand the dozens of machines used to move material. They talked with the men who actually operated the machines, and with the men whose work involved the choice of the best devices for specific classes of transferation.

As a result of these visits into industrial plants of all sorts one single purpose has guided the writings, editing and arrangement of the volume, to produce a book which shall give the user the material handling information he needs most in a highly accessible form.

Such information on machines, systems and methods has been gathered from the best available sources. It has been written and edited by men who know their field. And it has been so arranged that the man who needs answers to material moving problems can get them easily.

For every man whose work has to do with the moving of materials of any sort, the Material Handling Cyclopedia carries a wealth of practical help.

With its description and illustrations of dozens of different sorts of material handling machinery contained in one volume—the Material Handling Cyclopedia is of constant value in every transferation problem.

Naturally the number of copies of this book is limited, and its circulation will be restricted to those branches of engineering which have to do with material handling.

Since the first announcements, orders for the book have been coming in unsolicited. Enthusiasm for the book and for the valuable help it contains has been expressed on all sides. In order to be certain of receiving a copy, reservation should be made at once. The cost is ten dollars per copy.

SIMMONS-BOARDMAN PUBLISHING COMPANY, NEW YORK, N. Y.

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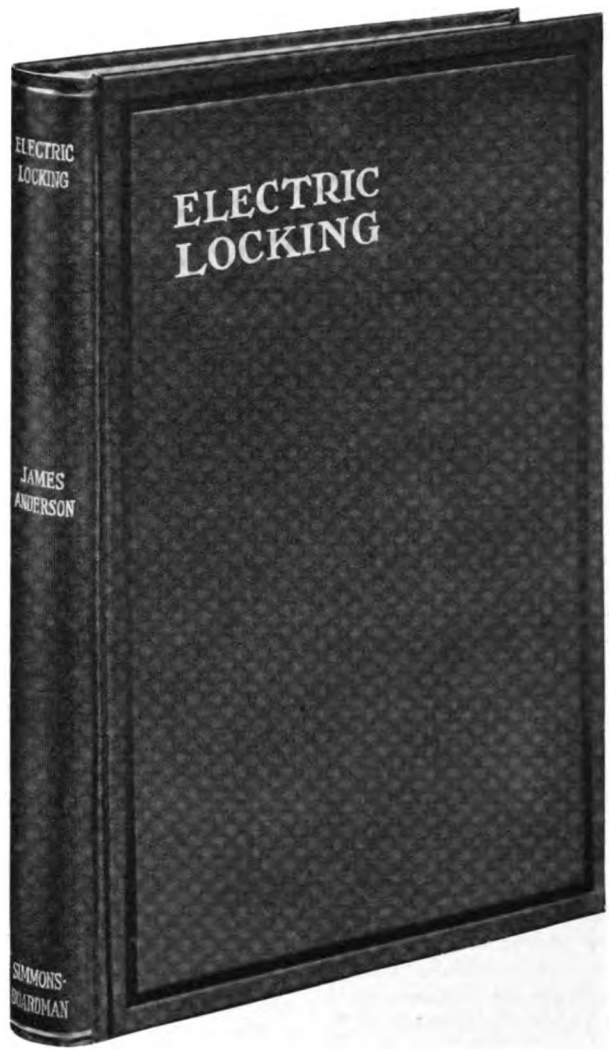
Electric Locking

By James Anderson, Signal Inspector, New York Central Railroad, 214 pages, 6 in. x 9 in., fully illustrated by diamgrams. In this book the author gives in detail the methods used in modern railway signaling practice to secure increased safety by decreasing the human element as a vital factor and substituting the more dependable automatic operation of devices—Electric Locking.

So little information is to be had on this important subject that this book which covers the subject in a very complete way, and is written in language which is sufficiently simple to be easily understood. has proved its value to railroad men.



Starting with the inception of electric locking in chapter one, which treats of preliminary considerations, classification; evolution; kinds of apparatus; track instrument; relays; indicators; annunciators; time release; mechanical time locks; lever locks, etc., the author devotes the second chapter to The Track Circuit, devoting chapter three to Trap Circuits.

The former chapter treats of single and double rail; normal open, location of relays, broken rail protection, fouling rail protection at crossings, turnouts, switches, crossovers, slip switches and gauntlets; while the latter goes very thoroughly into the subject of trap circuits.

Indication locking is covered in chapter four, which discusses indication for mechanically operated signals, for mechanically operated switches, reliability, dynamic indication, polarized switch indication, electric interlocking. G. R. S. scheme, Hall scheme, Union A. C. Indication, Union Bi-current; Union, Type F, and Electro-pneumatic.

The Detector Bar, lockings at mechanical plants, relays vs. lever locks, electric bolt-lock, precautions and designs are gone into in the chapter on Section Locking, while Route Locking is the subject of chapter six, which covers: Purpose, requirements, grade crossings not interlocked, crossing releases, door locks, stick release, locking at junctions, route levers, emergency releases, combined route and indication locking and at power interlockings.

Stick Locking follows, a chapter treating of—requirements, time locks, time releases, crossing protection, emergency releases, etc., etc.

In chapter eight, Approach Locking is covered very fully, the requirements are explained, advantages and disadvantages are discussed and other subjects include—audible annunciator, stick relay energized and de-energized; on single track; at electric railway crossings, at power interlocking. Combined approach and indication, emergency releases, advance locking and lever locks.

Sectional Route Locking is next covered, the term is defined, the requirements enumerated, and the various methods which may be employed to accomplish sectional route locking are given in nine different schemes.

Check Locking is the subject of chapter ten, and requirements, arrangement of mechanical locking, traffic preference, the Tower Director, and advance signal arrangement are covered.

Outlying Switch Locking follows and is very fully covered—mechanical arrangement, electric arrangement, hand switch control, indication, lever lock control, tower instrument control, locking at power plants and communicating devices — being among the many subjects treated.

Chapter twelve is devoted to Bridge Locking, and control of bridge engine or motor, bridge locks, rail locks, circuit controllers, bridge coupler and track circuits receive careful attention.

Testing is the subject of the next to the last chapter, while Maintenance—covering safety precautions, failure emergency instructions, inspection, lever locks, lever indicating parts and failures—is the subject of the final chapter. Price, cloth bound $2.50.

Book Department

The Book Department of The House of Transportation is prepared to furnish books on both land and water transportation. A new and comprehensive catalog of books on railway subjects, selected and approved by the Editors of Railway Age, Railway Mechanical Engineer, Railway Electrical Engineer, Railway Signal Engineer and Railway Maintenance Engineer, is now ready and will be sent free on request. A catalog of Marine books is now in preparation.

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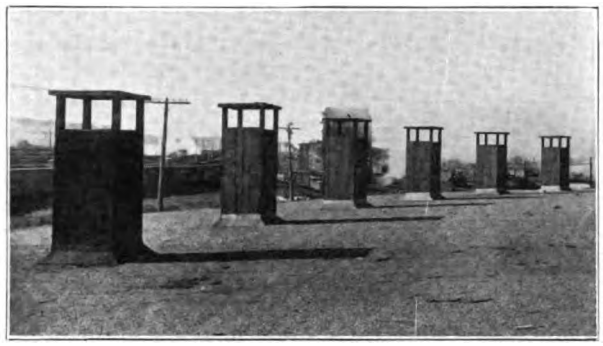
MILL TYPE SMOKE JACKS AND DOORS

General

One of the interesting developments of the present period in railway building construction is the extensive use made of rectangular shaped stationary hoods, spacious stacks, and wood construction in smoke jacks for engine houses. This tendency on the part of many railroads is a consequence of the increased attention



Mill Type Smoke Jacks, C. P. Ry.

being directed both to the making of these shops more attractive to workmen and to increasing the general efficiency of engine house operation, the basic need, aside from questions of cost and upkeep, being a means of removing the copious volumes of gases and smoke from live engines as rapidly as generated, while not entailing the necessity of accurately locating or "spotting" engines, whose effectiveness will be the least subject to neglect or careless attention on the part of the engine men, which will allow such shifting of engines as is often required in making running repairs, and which will permit work to be done on any part of the engine up to the time of its departure from the house without inconvenience from the suffocating gases.

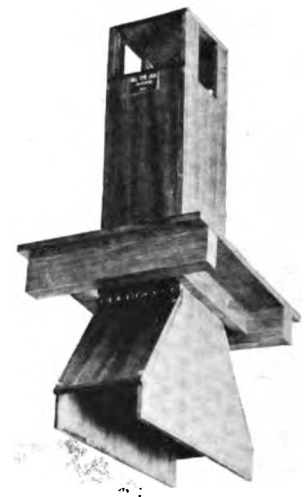
The Smoke Jack Co. Products

The Smoke Jack Company, 131 Coleridge St., East Boston, Mass., devotes its attention to the manufacture of this type of smoke jack, and to the manufacture of engine house and shop ventilators. The jacks are standard equipment on one transcontinental railroad and are used to a number in excess of 1200 on various other railroads of the United States and Canada.

They are built entirely of wood, the material consisting of selected strips of wood, 2 in. square, surfaced on all sides and treated with a fire-resisting compound. The method of construction is that of assembling the strips in sections. Each section is built to template, the strips being applied successively and fastened sidewise throughout their length to each preceding strip, by specially heavy corrugated nails, inserted to stagger with the nails of the preceding strip at intervals of 4-in. and of a length capable of penetrating 2½ thicknesses of wood. This method of construction, together with the shape of the sections, affords a high degree of strength and stiffness to the structures, sufficiently so as to make it unnecessary to reinforce it with framing, or when erected, to provide bracing, guy wires, or other supports. Inasmuch as each strip is applied over the nail heads of each preceding strip, the construction also affords adequate protection to the only metal used in the structure (with the exception of wood screws employed in assembling the sections) from exposure to the corrosive action of the gases in the smoke.

The jacks are shipped to the site of the work in these sections and the wood screws are applied from the outside. In order to protect this metal as well as that of the nails from exposure, the heads are countersunk and covered with a plastic cement. Smoke jacks of this kind have been in service for many years without showing weakness to the exposure, to the heat encountered, or from ageing, and tests extending over long periods have tended to show that the effect of smoke and gases upon the wood is preserving rather than destructive.

In these jacks the sides of the hood are extended sufficiently low to overlap the engine stack, and holes are provided in the base of the smoke jack stack to permit the escape of any smoke between the hood and the roof. These jacks are built in sizes having hoods 2 ft. or more wide, 8 ft. or more long, and with stacks of any height. They are supported solely by a collar above the roof, assisted below the



Showing Construction of Mill Type Smoke Jack

roof by flashing. They are not undesirably heavy and require little if any roof reinforcing, the weights of jacks 2 ft. 6 in. wide, 8 ft. long, and 15 ft. high averaging about 700 lb.

Ventilators

The Ventilators built by the Smoke Jack Company are fabricated in the same way as the Smoke Jacks. They are being used extensively for blacksmith shops and roundhouses. It has been found that very much better ventilation is obtained in a roundhouse if one of these ventilators is placed in the roof just inside each door, as it aids very much in keeping the house free from smoke when the doors are shut.

THE SMOKE JACK COMPANY, EAST BOSTON, MASS.

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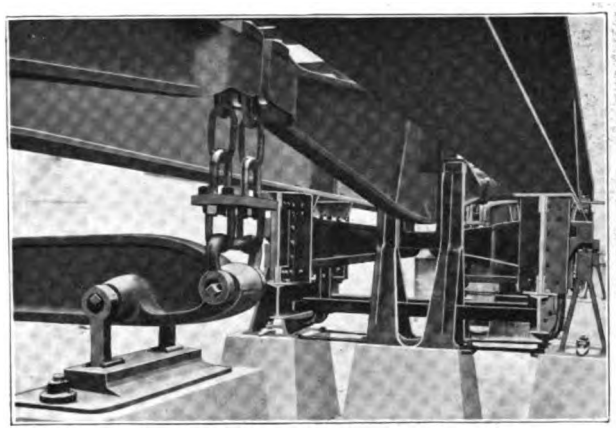
General

The Standard Scale & Supply Co., Pittsburgh, Pa., is the manufacturer of a line of scales comprising types and sizes for every railway need, from the weighing of mail packages and small merchandise to carload quantities. Its line includes counter scales, portable platform scales, floor scales, and track scales. This company has been engaged in the manufacture of this line of products for over 25 years and is now one of the largest organizations of its kind in the country. Its scales are used by railroads, industrial organizations and mercantile establishments throughout the United States and in foreign countries. The company maintains sales offices in New York City; Philadelphia, Pa.; Baltimore, Md.; Cleveland, O.; Dallas, Tex.; and Chicago.

Track Scales

It is of the first importance that track scales in railway service afford precision in all weighing operations, owing to the use regularly made of the records as the basis for the computation of revenue. With due consideration to cost, it is evident that a scale which cannot be relied upon under such conditions is likely to occasion losses far in excess of any saving which might have been made in initial cost.



View of "The Standard" Track Scale Pit Showing Lever System

The track scales of the Standard Scale & Supply Company constitute equipment developed to afford this precision along with a high degree of durability. The scales are of the modern suspension bearing type, comprising a construction in which the main girders are carried upon the main levers by means of suspension bearings that work on the pendulum principle. Those bearings are equipped with self-alining rocker blocks capable of absorbing all deflections and horizontal thrusts before they

"The Standard" Pin Recording Beam for Track and Floor Scales

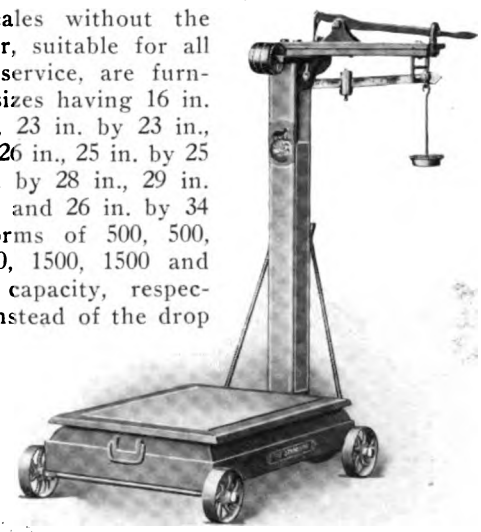
reach the lever system. The lever system is equipped with the modern improvements for making adjustments, both as to the ratio of levers and for vertical distances. The construction is massive and all parts of the mechanism are made easily accessible for inspection.

For use with these scales the company furnishes single, double and triple beams, but directs the attention of the railroads particularly to "The Standard" Pin Recording Beam, a single beam capable of indicating the weight and recording it upon two or more cards in a single operation, accomplished rapidly. The cards are carried in an attachment on the poise, the weight being registered by punching. This beam with the attachment can be applied to any make of scale. Type Registering Beams are also furnished.

Portable Platform Scales

For general platform weighing such as is encountered in railway service, the company makes two styles of portable platform scales, one with, and the other without, the drop lever for relieving the bearings of wear and protecting the mechanism from breaking during loading, unloading, or moving of the scale. Both scales have brass beams and sliding poise, the latter being fitted with a set screw for clamping. In the sizes for weighing 1000 lb. and over, the scales have their pillars reinforced with iron braces. The platform panel boards are of hardwood.

The scales without the drop lever, suitable for all ordinary service, are furnished in sizes having 16 in. by 25 in., 23 in. by 23 in., 17 in. by 26 in., 25 in. by 25 in., 21 in. by 28 in., 29 in. by 29 in., and 26 in. by 34 in. platforms of 500, 500, 1000, 1000, 1500, 1500 and 2500 lb. capacity, respectively. Instead of the drop



"The Standard" Platform Scale-Drop Lever Type

lever these scales have the familiar beam clamp.

The drop lever style of scales are furnished in sizes having 17 in. by 26 in., 21 in. by 28 in., 26 in. by 34 in., and 31 in. by 40 in. platforms of 1000, 1500, 2500, and 4000 lb. capacity, respectively. In the scales of 500 lb. capacity the beam is graduated to 50 lb. by ¼ lb. subdivisions, all others to 100 lb. in ½ lb. subdivisions.

Warehouse Scales

For warehouse purposes, the company makes a style of floor scale having, above the floor, short iron pillars, hardwood shelf, beam hangers, and a single or double beam graduated to 500 lb. by 2 lb. subdivisions. These scales are furnished in sizes having 6 ft. by 3 ft. 10 in., 6 ft. by 4 ft. 11¼ in., 6 ft. by 4 ft. 11¼ in., 8 ft. by 6 ft. ⅝ in., 9 ft. by 6 ft. 11 in., 6 ft. by 4 ft. 11¼ in., and 8 ft. by 6 ft. ⅝ in. platforms of 4, 4, 6, 6, 10, and 10 tons capacity, respectively.

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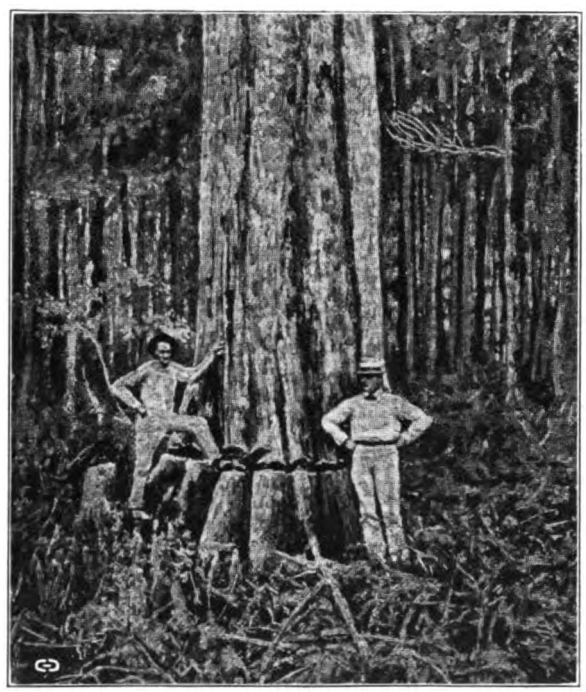
General

The Southern Cypress Manufacturers' Association is an organization of tidewater cypress manufacturers, which was formed in 1905 for the purpose of bringing about uniformity of grades and promoting standardization in the manufacture of cypress lumber. The production of the mills controlled by its members amounts to approximately 500,000,000 feet annually, or slightly more than half of all the cypress produced. The offices of the association are at New Orleans, La., and Jacksonville, Fla.

Tidewater Cypress

Cypress commonly known as bald cypress, or, botanically, as Taxodium distichum, has come to be known as the wood eternal, or the wood that defies decay. The cypress which possesses in the highest degree the quality of resistance to decay is that which grows near the South Atlantic and Gulf Coast, commercially known as "Tide-Water" Cypress. Cypress grows in swamps, which are covered with water much of the time. The tree attains a height of from 75 to 140 ft. and is from 3 to 6 ft. in diameter. The timber is found in commercial quantities in all of the Gulf States, along the Atlantic seaboard as far north as Maryland, and in the Mississippi valley as far north as southern Missouri.

As regards its physical properties cypress is light, soft, fine grained and straight, and is easily worked. The "heart-wood" is very durable, especially where moisture, heat and other elements are present which tend to hasten decay, such as when the wood is in contact with soil. The particular usefulness of cypress is in those structures where strength is not a governing requirement. While for numerous uses the sap material is just as good as the heart, it is important, where resistance to decay is a vital factor, that all-heart cypress shall be specified.

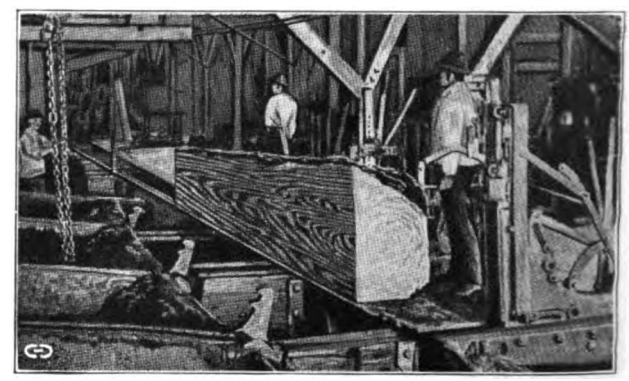


A Healthy Cypress Tree

It has been estimated that one-third of the cypress in the United States is diseased with a fungus popularly known as pecky, peggy, botty or some similar name. This variety is known as Pecky cypress and is characterized by the presence in the wood of numerous holes filled with a brown powder. While this gives it the appearance of being decayed, it is nevertheless one of the most decay-resisting woods known. The fungus works from the top of the tree downward, leaving holes from ¼ in. to 1 in. wide and several inches long, but disconnected so that a tree thus attacked never has been so weakened as to be blown down. It is a curious, but well established, fact that the disease quits working at once when the tree is felled; and it is even believed that the disease acts as a preservative upon the wood which remains.

General uses of Cypress

Cypress has numberless uses in the arts. At least half of the high grade cypress manufactured is used for interior trim, either finished in natural color or stained. The fine natural grain of the wood is well brought out by staining, either by the penetrative process or by surface application. When quartered and sawn it lends itself well to cabinet work and is therefore much used in offices. The wood contains little resin and thus offers a good surface for paint.



A Saw Line in Cypress Showing the Grain

Cypress serves equally well for the parts of buildings exposed to the weather and, as siding, wears out before it decays. Cases are known wherein cypress siding has endured for 100 years without repairs. Its decay resisting qualities make it eminently suitable for lasting construction. As it does not warp, twist, swell or shrink it maintains a good appearance as long as the building stands. It is placed as cornice, gutter, outside blinds, etc., and is much used for porch floors and steps.

While cypress cannot be substituted for the most exacting kinds of tight cooperage, it is adapted to practically all other kinds of cooperage by the absence of knots, which might cause leakage; by freedom from stain or chemicals, through which the contents might be injured; and especially by the long period the wood may be expected to last.

As regards the quality of durability in any climate, cypress is superior to all other woods for shingles, whether they be used for the roof or sides of a building. Because of the rot-resisting qualities of the

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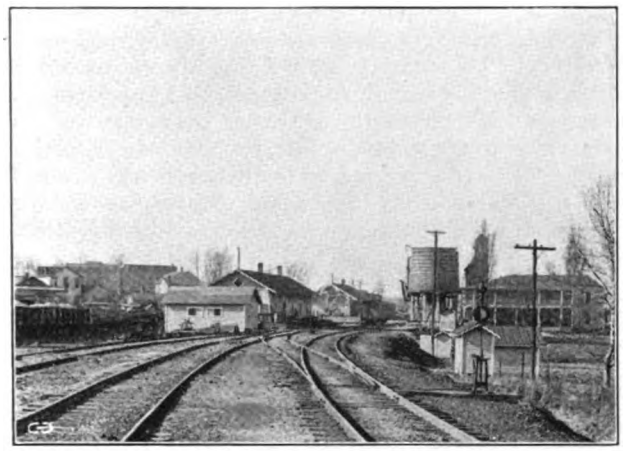
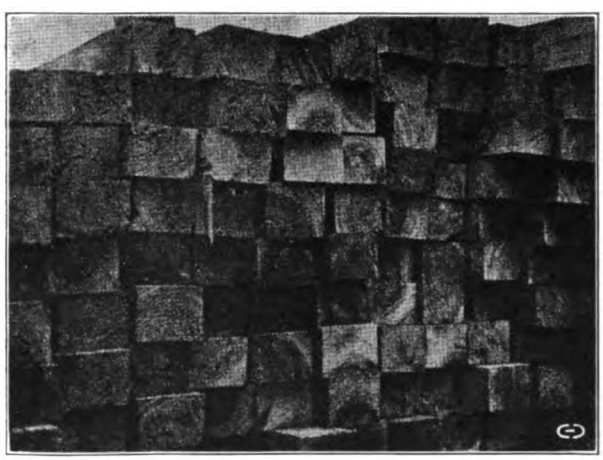
wood these shingles will last almost indefinitely. While in the larger part of the country their cost is a little more than other varieties, their long life makes for a larger ultimate economy.

Railway uses of Cypress

Besides interior trim, siding and shingles, which are common to all building construction, cypress is especially adapted to railway water tanks, of 50,000 to 100,000 gal. capacity. The durability of cypress tanks is specially marked under the corrosive influence of certain waters, or the effects of the salt air in regions near the coast. By reason of the light weight of the wood, the tanks are put in place easily, and may also be dismantled and relocated with equal facility. Cypress is also much used for telegraph and telephone poles throughout the region of its growth, and is made into fence posts and rails, frequently forming an entire picket fence. The wood is coming extensively into use for capping and trunking in signal work, both that which is exposed and that which is buried. Cypress is being applied to many uses where formerly white pine was selected, and it has been found not only cheaper but in some ways better,



Cypress Tanks on the Railroad



A Pile of Pecky Cypress Ties

telephone boxes and switchboards being notable examples in this category.

The use of Pecky Cypress, already large, is an increasing one. Large numbers of Pecky cypress ties are installed every year on the railroads where they are giving good results. These ties are especially popular for swampy country or in tunnels where dampness is nearly always a factor. The peckiness does not affect the life of the ties, and there is sufficient strength for the support of the track and ample holding power for the spikes. Pecky cypress is also useful for bridge floors, foundation timbers, culverts, drain boxes, walks, benches, railings, and in fact for any wood construction where resistance to decay is essential. Immense quantities of pecky cypress are made into fence posts for which the lasting qualities of the wood make it specially suitable.

Relation to the Industry

The Southern Cypress Manufacturers' Association has rendered an invaluable service to the industry by assuming control over the grading rules covering cypress. It early took the view that the grading rules should be tightened up by admitting less sap, fewer knots and other defects into a given grade. By reason of the slowness of growth of cypress there is no second growth available for manufacture into lumber. The material manufactured today is from the same class of timber as that manufactured 50 years ago and this will continue to be the case as long as the supply lasts.

As part of its service to the trade the association maintains inspectors at the mills to insure that the grading rules are correctly interpreted and that the grading of the lumber is strictly in accordance with the rules. Inspectors are also assigned to the northern country to prevent the substitution of lumber not coming within the classification of tidewater cypress.

The association has adopted the trade mark shown in the illustration, which also carries the number of the mill for identification of the product. This trade

Mark Which Identifies Tidewater Cypress

mark is stamped on one or both ends of every timber, board and bundle of cypress, such as siding, flooring, moulding or shingles. The purpose of the trade mark is to insure to the consumer that the stock purchased is manufactured from tidewater cypress and therefore from the best quality of timber. The presence of the trade mark also furnishes assurance that the material, both in respect to grade and manufacture, is strictly in accord with the high standards fixed by the association.

It is the definite policy of the association to direct the employment of cypress only into those fields to which it is wholly adaptable. For this object it has issued a series of books giving the specific applications of the wood, some of these being devoted to an elaboration of the special features of such use. Many of the largest railways companies in the country have found the use of cypress a paying investment. The association is prepared to supply data substantiating its claims for economy through the use of this material.

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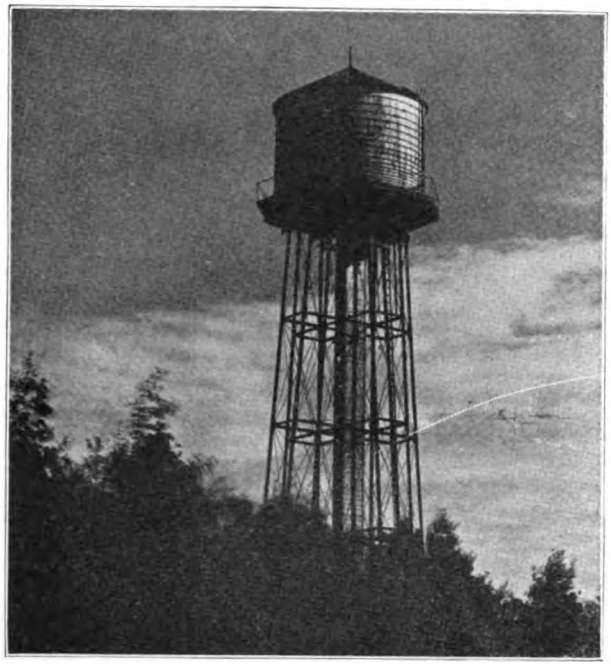
CYPRESS TANKS

General

Stearns cypress is the principal product of The A. T. Stearns Lumber Company, Neponset, Boston, Mass., a large concern which has had over 70 years' experience in the lumber business. This company supplies all kinds of lumber for a variety of building and industrial purposes, but specializes in cypress, a wood well known for its durability. The Stearns cypress is obtained



Cypress Tank Built by A. T. Stearns Co.

from large cypress swamps controlled by this company in Florida, and is employed extensively in the United States and in foreign countries for flooring, siding, shingles, and all kinds of cooperage. Tanks made of this product are widely used by the railroads for water supply. The wayside tank of 50,000 or 100,000 gal. capacity is a familiar adaptation of Stearns cypress to a field where its distinctive advantages have been amply demonstrated.

The demand for Stearns cypress is such that the company carries ordinarily about ten million feet of the lumber in stock in various stages of seasoning. Its success in establishing this market is the direct result of the merit of its products, backed by an efficient organization. The A. T. Stearns Lumber Company is both a merchant and manufacturer, having its offices in Boston, where it also operates a large factory equipped with modern machinery. The location of the plant provides facilities for shipment by rail or water, and this element of the business, together with a common control of the sources of supply, the lumber mills and the factory, and the large amount of material carried in stock, enables the company to supply a high grade of material promptly.

Wood Tanks

Most of the water tanks used for railway service in the past have been constructed of wood, and while other materials have been used for this purpose, there is no question, but that timber will continue to enter into the construction of tanks of 100,000 gal. capacity and under. The reason for this becomes apparent when a study is made of the wood tank in its relation to the railway field. Wood tanks lend themselves readily to problems of construction along the railroad. Consisting merely of staves and hoops, the materials can be handled easily and the tanks erected upon the ground or upon towers at terminal or isolated stations by the regular maintenance crews without the assistance of specialized workmen or special equipment. With like facility the tanks can be repaired or dismantled and set up at other points.

The dependable service and long life of wood tanks, when properly constructed and of suitable materials, are facts which are well established by experience. The characteristic durability of the wood tank, under the severe conditions resulting from the attack of salt air or the corrosive properties of the contained water, effects a distinct economy in maintenance by reducing the amount of repairs required and the frequency of repainting. Market conditions are often a further factor in determining the selection of the wood type of tank in preference to other types. Suitable material of other kinds cannot generally be obtained as cheaply or as promptly as wood, and this is particularly true at the present time. This is an element in the building of water tanks which may well be considered in the matter of renewals, as well as of initial construction.

The Stearns Cypress

The value of cypress as a material for water tanks is generally recognized. It is light in weight, of soft texture, fine and straight grained, easily worked, and very durable in contact with soil and weather. In the report of the proceedings of the American Railway Bridge and Building Association for 1915, the statement is made that cypress is "beyond question the best (wood) for water tanks." The average life of cypress railway tanks is in excess of 30 years, to attain which it has only been necessary in many cases to keep them well soaked with water and to paint and renew the hoops as may be required.

Stearns cypress tanks are in the class of water tanks which are properly constructed and of a suitable grade of material. The cypress used in them is obtained from specially selected portions of the tree, is thoroughly seasoned, firm, straight, and free from pitch pockets and unsound knots. The tanks are built by skilled workmen in the companys' modern factory at Boston, and are carefully inspected before leaving the works. In every detail of construction the tanks receive the benefit of the company's long and specialized experience.

The company constructs all kinds of tanks, both circular and rectangular, and in capacities from 25 gal. up to 125,000 gal., but specializes in the manufacture of the 50,000 and 100,000 gal. standard railway tanks, the latter conforming to the specifications of the American Railway Engineering Association. Unless otherwise specified the tanks are equipped with round iron hoops and malleable lugs in preference to flat hoops, the former presenting less surface for corrosion and as a result requiring less frequent renewals. When desired, the Stearns tanks are equipped with conical roofs, frost ceilings, float indicators, and either circular or square frost boxing for the pipes leading into the tanks.

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General

The Track Specialties Company, with offices at 29 Broadway, New York, manufactures rail joints, of the standard, step and insulated varieties; rail anchors and tie plates; guard rail clamps and other appurtenances of switch connections; rail benders, derailers and car stops. The company is also a dealer in new and relaying rails, frogs, switches, track bolts and spikes. Its standard joint, derailer and rail bender are sold under the trade name "Superior," while its other track devices carry the name "Trasco." The standard joints are supplied in either rolled steel, cast steel or malleable iron as may be specified. In order that the compromise joints may fit accurately the rails for which they are intended, they are cast from special patterns, affording evidence of the particular care taken to furnish exact fit for this as well as other materials supplied.

Trasco Guard Rail Clamps

The Trasco Guard Rail Clamp has the usual features of a solid yoke (which in this device is made in a forging of bridge steel); a wedge designed for holding with a cotter; a large and small filler, one of which has two lugs to keep both in place; and a deep fitting brace. The peculiar advantage of this type of clamp is the efficient manner whereby the yoke is seated at each end, by which marked facility in application is obtained. The adjustments are by ⅛-in. steps, and the wedge, when driven home, is secured in place by cotters.

Trasco Guard Rail Clamp.

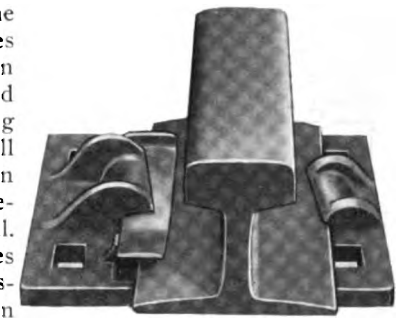
The Trasco Compromise or Step Joint

The Trasco Compromise or Step Joint, made by The Track Specialties Company, embodies the essential points of the Superior Joint, with the addition of lugs for slot spiking. As compromise joints must be supplied in rights and lefts, the outside bar in this joint is provided with a reinforced head. The deep flanged truss in the center, and the base support for the rails on the ties, are exclusive features of the Trasco joint. These two features in combination supply an exceptionally strong joint and one that is designed to perform satisfactory service. The joints are cast from special patterns to fit accurately the rail specified, and the sections to which the ends apply are shown legibly on the splices in raised letters.

Trasco Compromise Joint.

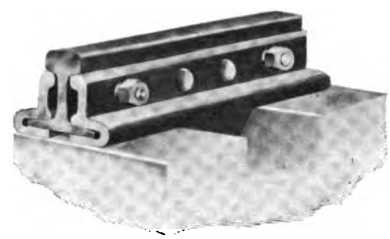
The Trasco Anchor Tie Plate

The Track Specialties Company manufactures tie plates and rail anti-creepers and also a specialty, The Trasco Anchor Tie Plate, in which these two are in combination. The Trasco Anchor Tie Plate has bottom ribs to secure the tie plate upon the tie and a corrugated upper surface to increase the strength of the plate. Essentially, the Trasco Anchor Plate is a tie plate with five bottom ribs running longitudinally with the tie and having holes for four spikes, which together anchor the plate to the tie. A split wedge grips the rail firmly and is backed up by a substantial hook on the plate casting; a riser on the plate, which spreads the split wedge, causes the upper flap on the wedge to bend upwards, assuring that the device will not get loose in spite of the rebound of the rail. These anchor plates cannot be dislodged by frozen ballast when the rail moves backward, and are therefore not liable to be lost, as sometimes happens with certain types of rail anti-creepers.


Trasco Anchor Plate.

The Superior Rail Joint

An important product of the Track Specialties Company is the Superior Rail Joint, which is distinguished from other types of joints by having both a base support on the ties and a truss member in the center, whereby two main features of rail support are combined in a single joint. It is not usual to provide spike slots in this joint, although this is done when desired. Omission of the slots is in accordance with the idea which is gaining ground that the only duty proper to exact of the joint is support, and that resistance to rail creeping can best be obtained by the use of rail anti-creepers. In the Superior Joint the jaw which engages the rail base provides the means of absorbing the outward force tending to strain the bolts, and insures that they will remain tight. The two splices are brought close enough together under the rail to obviate any undue shear upon the rail section, and in consequence tie plates are not required at the joints.


Superior Rail Joint.

Special Devices

The Track Specialties Company also manufactures the Superior Derailer, both hand throw and mechanically operated, and the Trasco Car Stop. The Trasco Track Shim is designed to afford a means by which the shims in track will not only be held securely, but will permit of being changed to suit varying conditions of heaving track. Standard and special track fittings, include rail braces, guard rail braces, rail chairs, rail clips, step plates, angle bars, etc.; and in fact everything for track is handled by the Track Specialties Company.

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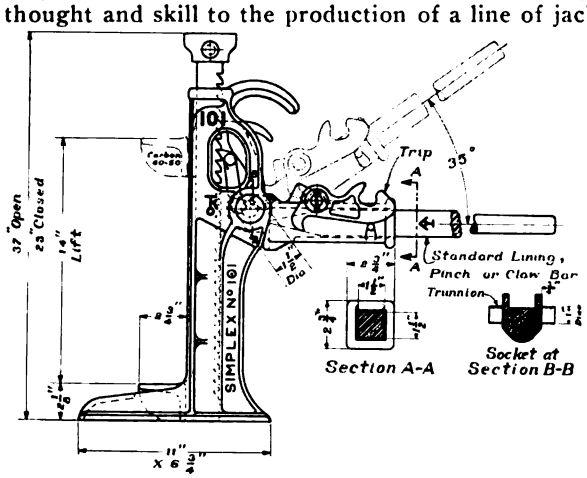
General

Templeton, Kenly & Co., Ltd., are the manufacturers of Simplex Jacks designed for use in track, bridge, car and locomotive work; for pole pulling and straightening; for mining, and for industrial, automobile and motor trucks. Their modern plant, covering a city block in Chicago, radiates success internally and externally. The company was organized in 1899 and has branches in Canada, Europe and Australia. Since its formation, a corps of trained men have devoted their energy, thought and skill to the production of a line of jacks



Details of Construction of Simplex Jacks

to meet the new industrial or changing conditions of railway operation and maintenance. In this advancement not the least of the problems to be solved has been the overcoming of the inadequate design and improper use of jacks. That these efforts are meeting with success is shown by the extending application to track jacks of the square socket, designed for effective use of the lining bar as a lever in place of the wood pole; the increasing use of the Simplex single-acting track jack; the practical differentiation between the surfacing jack with an 8-in. raise and the ballast jack with a 19-in. raise; and recognition of the principle of entire interchangeability among the parts of both types of jacks.

Simplex Jacks

Simplex Jacks are designed and built to serve the purpose of raising and sustaining continuously the maximum load to which they may be subjected in service. These jacks are constructed along exclusive lines and with a well-tested mechanism. A distinguishing feature of the design is the heavy 1-in. steel fulcrum trunnion, cast integral with the steel lever socket (see illustration Simplex Track and Ballast Jacks), which rotates in hardened steel, lubricant-retaining bearings, keyed to avoid rotation or lateral movement. The dust-proof bushings insure lubrication through an entire season without attention.

The materials used in Simplex jacks are, in general, malleable iron for the standards; crucible steel for the sockets; and drop forgings for the rack bar, pawls, bushings and keys. The liberal use of alloy and high carbon forgings and the safeguarding of all details of the specification are necessary provisions for meeting the severe requirements of railway work today; and it is well recognized that the strength of the jack and its sufficiency for the service in which it will be used are essential matters for the furtherance of the "safety first" idea.

The Simplex Track jacks include both single and double-acting jacks, tripping from all positions or lowering tooth by tooth as required.

Simplex Track Jacks

One of the first radical departures from accepted track jack design, originated by and brought into use through the ingenuity of Templeton, Kenly & Co., Ltd., was the application of the Simplex square lever socket to new or old track and ballast jacks to facilitate the use of a lining bar as a jack lever. This use of the bar had long been in vogue in a makeshift way, brought about by the necessity for increased leverage in raising track laid with rails which had grown one-half heavier in section and which, by their greater stiffness, involved increased scope for every lift; in which one-third more ties, larger and heavier than in the past, had become necessary through the increasing weight of traffic; and in which the lighter gravel and cinder ballast had progressively given way to stone. Along with the manifest increase in the weight of track has also come the substitution of a generally lighter type of men in the labor forces.

The increase in power of the track jack when used with a 66-in. lining bar over that with the 48-in. wood pole, may be figured readily as 37½ per cent. The actual ratio of weight to power in the former case. assuming 21/32 in. fulcrum centers and a 68-in. lever arm, is as 1 to 104. The importance of this feature is that it avoids the need for putting two men on the lever; the Simplex is distinctly a one-man jack.

This increased power presupposes that all parts of the jack, standard, rack bar, pawls, socket and trunnions are strong enough to withstand the additional load which may and assuredly will be imposed upon the jack as a result of the increased leverage. This

Model	Mechanism	Type	*Cap. Tons	Height Inches	Lift Inches	Weight Lbs.
No. 101 Simplex	Double-Acting	Track	10	21½	14	58
No. 106 Simplex	Double-Acting	Ballast	15	28½	19	70
No. 116 Simplex	Single-Acting	Surfacing	10	15½	8	46
No. 117 Simplex	Single-Acting	Track	10	20½	12½	53
No. 118 Simplex	Single-Acting	Ballast	15	28	18¾	70

*Since the parts of the 10 and 15-ton jacks are interchangeable, the capacities are identical, but to avoid confusion, the capacities are given under which these track and ballast jacks are universally specified.

MATERIAL SPECIFICATIONS

Standard—Malleable Iron; Lever Socket—Crucible Steel; Cap—Malleable Iron; Rack Bar—Drop-Forged Steel, 40-50 Carbon; Pawls—Drop-Forged Steel, 40-50 Carbon; Bushings—Hardened Steel.

Simplex Track and Ballast Jacks

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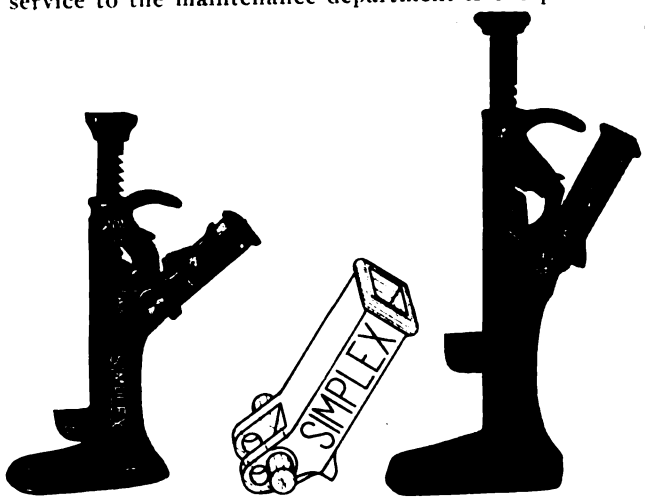
is insured in the Simplex track jacks through a common construction of these members for interchangeability between the 10-ton and 15-ton jacks. This uniformity also facilitates the replacement of parts and reduces the stock account materially.

The question as to the kind of jack to be used in track work had received careful study. Practice heretofore has favored the double-acting jack, probably because it has always been considered to be quicker and more accurate. Since the double-acting jack raises only a half notch on the upward and a half notch on the downward stroke, while the single-acting jack raises the full notch on the downward or effective stroke, there is no apparent difference in time; but as a demonstrable fact, the latter jack raises the load faster. Maintenance men well know that the displacement of the jack from the vertical position, which tends to throw the track out of line, occurs almost entirely on the upstroke of the double-acting jack.

An important point in Templeton, Kenly & Co., service to the maintenance department is the part it has played in the establishment of the 10-ton jack with an 8-in. raise as the practical type for track work, and of the 10-ton jack with a 14-in. raise and the 15-ton jack with a 19-in. raise, for ballasting work. Maintenance rules require that the lifts shall be so regulated as not to strain the joints or bend the splice bars. An examination of many of the rack bars from jacks having a 14-in. raise which had been worn out in regular maintenance service proved that not more than one-half of the teeth had been used enough to show any sign of wear. Since height produces weight and cost, the use of the low lift jack for surfacing and general work, leaving the jack with higher lifts to the greater requirements of the heavier track work, contributes both to economy and efficiency.



Simplex Track and Ballast Jacks

Simplex Bridge Jacks

The Simplex Bridge Jacks, with a capacity of 15-tons and with lifts of 11½ in. and 17½ in. are specially designed for bridge, track crossing and heavy construction work. They are single-acting and lower the load by stages.

The mechanism of these jacks is uniform with all Simplex car jacks and their safety has been recognized by the award of the Gold Medal of the American Museum of Safety.

Simplex Bridge Jack

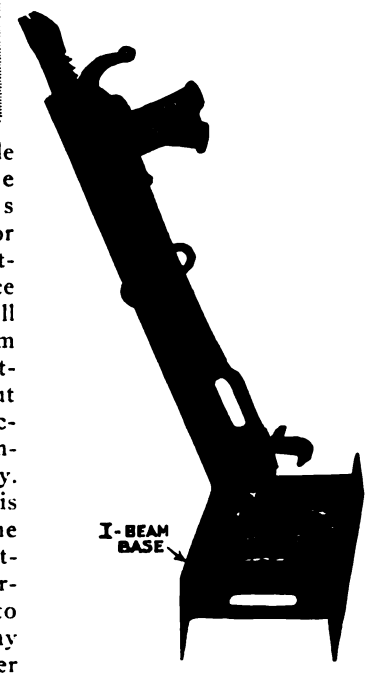
Simplex Bridge and Car Jacks operate on the down stroke—the effective stroke—of the lever. They are extremely simple in their design and maintenance, and well justify their internationally known trade mark "Simplex." The material utilized and its finish is indicative of the pride which the manufacturers have in their product.

The Oval Socket and Oval Pole is an exclusive Simplex feature. This oval pole produces safety in that it cannot be inserted in the socket "cross grained" and, being unbreakable, it protects the operator and his company against accidents and their attendant expense. By virtue of the oval shape adding strength to the pole, it is practical to use longer lever poles. The additional length of the lever produces greater man power with complete safety.

The Simplex expansion rivet is used in all Simplex jacks in lieu of screws which in the past, by working loose, frequently caused jacks to become inoperative. The expansion rivet is of soft steel, hollow, and with a funnel-shaped interior surface which becomes reversed under the wedge action of a tool steel expander driven by a hand hammer.

Simplex Pole Jacks

The Simplex Pole Pulling and Pole Straightening jacks are necessary tools for the telegraph department or the fence gang, since they will lift a pole or post from the ground or straighten it in place without digging, and in a fraction of the time formerly deemed necessary. The No. 318 Simplex is a tripping type and the No. 328 is the automatic lowering. The former may be tripped to low position from any point, while the latter lowers tooth by tooth.



Simplex Pole Jack

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General

The Union Furnace Manufacturing Company, Inc., Altoona, Pa., is a manufacturer of shovels, scoops, spades, ditching and drain tools and telegraph spoons and shovels. The entire energy of the plant is thus devoted to the making of a single line of tools employed principally on the railroads. The company's broad guarantee of its product insures the quality which is essential to economical maintenance.

Maintenance Shovel

The blades of Union Furnace shovels are made of high carbon crucible or open hearth steel, and the handles of selected northern white ash or hickory. For supplying its needs in the latter item the company has access to the best grades of ash and hickory wood. The shovels are inspected carefully for defects of workmanship and are given a factory test before being shipped. They are put up in bundles of six.

The shovels are furnished with malleable D grip, wood D grip or split D grip. The blades are polished when required, but for nearly all uses the black finish is recommended in preference. In the latter the hard, wear-resisting surface of the steel is not removed, as occurs in polishing, which exposes the fibres of the steel to rust, deterioration and rapid wear.

The Union Furnace Manufacturing Company maintains branch offices at New York City, Boston, Mass., Philadelphia, Pa., and Baltimore, Md.

Union Furnace Track Shovels

The square point shovel is employed in maintenance work for surfacing track, cleaning up roadway and handling the heavier bulk materials. The Union Furnace Manufacturing Company's track shovel is called the "R. R. and Contractor's Special," and is made in two sizes: Nos. 2 and 3, and in two grades, 1st Portage and 2nd Portage. The first grade is made of high carbon crucible steel of from 0.70 to 0.90 carbon, and the second grade of open hearth steel of about 0.70 carbon.

The 1st Portage shovels are guaranteed to stand

Union Furnace Track Shovel

a test with 200 lb. suspended from the handle while the blade is clamped in place at its mouth. This in a manner duplicates the way the trackman sometimes misuses the shovel in spite of instructions to the contrary. The best grade of northern white ash is used in the handles of the No. 1 grade shovels, while that used in the No. 2 grade is the XX grade.

Union Furnace Dirt Shovels

The round point shovel is preferred for all grading operations. The Union Furnace Manufacturing Company makes two grades of dirt shovels, the Vulcan and the Monarch, and these are furnished in any one of the three grips. This type of blade is also supplied with the long handle for use in the digging of holes.

Union Furnace Long Handle Shovel

These shovels are warranted to stand up well in the hard service in which they are generally employed.

Union Furnace Snow Shovel

The snow shovel manufactured by the Union Furnace Manufacturing Company is distinctly not a one-season shovel and for this object is made only in the first grade. It is of No. 15 gage metal, of 0.40 carbon steel and is thoroughly tested to insure durable service in the important

Union Furnace Snow Shovel

operation of handling snow. The company supplies samples of this tool to prospective buyers.

Union Furnace Scoops, Etc.

The scoop is generally subjected to a severe test in the handling of cinders and other abrading materials. Union Furnace Scoops are made in the Eastern and Western patterns of the hollow back or riveted back designs, and in all required sizes, the No. 3 being a common preference. These scoops are correctly designed to provide efficient as well as durable service, both in maintenance and in the more exacting operation of handling coal on locomotives. The telegraph spoons and shovels are of Eastern and Western designs and are made only in the first grade, with handles of selected hickory.

Scoop

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Electric Arc Welding

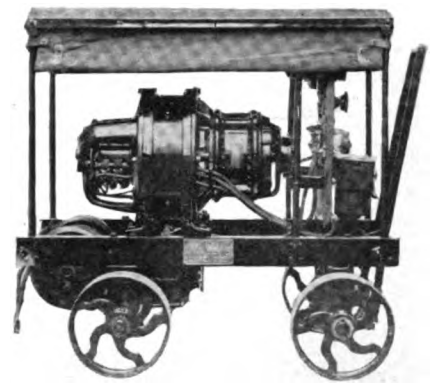
The process of welding and cutting by the electric arc has been of commercial value for more than 20 years. However, within the last decade, owing chiefly to the character and extent of the work performed by it during the war, on ships, in manufacturing and salvage plants, in railway shops, etc., and to improvements effected in methods and equipment, it has experienced an especially rapid growth and at the present time is employed extensively in cutting and in practically all operations of joining steel and iron. This process is establishing itself prominently on maintenance work as well as in the locomotive shop, stationary and portable outfits providing the means of performing profitably many kinds of work of which the building up of worn frogs, crossings and switches is an important one.

The process, as the name implies, is one depending upon the heat produced by an electric arc to melt the metal along the line of cutting, or to melt and effect the fusion of the welding metal with the objective mass, as the case may be. There are two distinct methods of thus employing the arc, the metallic electrode and the carbon electrode methods. In both methods the metal upon which the work is being done is made one of the terminals for the electricity by fastening one of the two electric wires to it while an electrode clamped in a holder provides the other terminal. In the metallic electrode method this electrode is the stick of welding material, the arc thus passing directly from it to the object being treated, carrying with it the melted metal of the stick, and depositing it upon the object. In the carbon electrode method a stick of carbon comprises this electrode and in welding work the welding metal is melted and applied as in gas welding or soldering. Obviously the metallic electrode method is exclusively a welding one and as such is the more generally used; more than 75 per cent of all arc welding being performed by it. The carbon electrode method is used for cutting and is also well adapted in welding where much filling-in is required.

Prominent features of this process are (1) immediate fusion of the metal resulting from a very high temperature produced in a small area, (2) practical elimination of troubles arising from expansion and contraction, (3) convenience and scope of application, (4) ease and speed with which dependable, high-grade work can be done, and (5) low cost. The cost of arc welding by well designed equipment is exceptionally small, some railroads, on the strength of this feature together with other advantages afforded by the process, continuing to use early types of machines in which less than four per cent of the energy generated is available. The process is not a hazardous one from the electrical standpoint and is distinctive particularly in the facility with which overhead work can be performed by it. In both methods the arc is established simply by touching the work with the electrode and withdrawing it about ⅛-in., the voltage under this condition amounting to about 20 volts in welding operations and the current varying from 50 to 200 amperes according to the thickness of the weld.

The USL Arc Welder

The USL Arc Welders are the result of the efforts directed by the U. S. Light & Heat Corporation, Niagara Falls, N. Y., a long established concern and the manufacturer, also, of the widely known USL car lighting equipments, to improve upon the early arc welding machines and to develop equipment capable of meeting the large need for high mechanical efficiency,



USL Arc Welder—Portable Type

inherent regulation, simplicity, portability, constant energy or current control, and reliability. Reports of various tests and records of service in practical applications, which are available, reflect favorably upon the machines and they are employed by several railroads. The machines are of the self-exciting variable voltage type designed for generating 200 amperes (or less) direct current at the voltage range required for arc welding. The equipment is arranged in stationary and portable outfits and is intended for use by a single operator. The outfits comprise a motor generator or a converter, as the case may be, a switch and meter panel, an arc stabilizing reactor, an electrode holder, a face shield, and, when in portable arrangement, also a truck and cable reel with two 50 ft. lengths of flexible cable. A complete portable motor generator outfit weighs 1,530 lb. and is so mounted as to be moved over a shop floor by one man without difficulty. For use where electrical power is not available outfits are made which include a suitable and compactly arranged gas engine.

The principal claims made for these machines are that they develop a high efficiency, insure an instantaneous response of the arc when the electrode strikes the object, protect the system against excessive current on short circuit while at the same time providing enough current above normal to protect the work locally on striking the arc, embody volt ampere characteristics that maintain practically constant heat in the arc, have no regulators to get out of order, and provide a positive steady current giving a uniform flow of metal into the weld.

The company maintains branch offices in New York City, Chicago, San Francisco, Calif.; Detroit, Mich.; Kansas City, Mo.; Washington, D. C., and an information bureau in London. The company also maintains a staff of engineers which is prepared to furnish information and assistance to interested parties regarding the USL equipment.

U. S. LIGHT & HEAT CORPORATION, NIAGARA FALLS, N. Y.

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General

The United Electric Apparatus Company, Inc., is a manufacturer, designer and engineer in electric and steam railroad signal apparatus, telegraph and telephone signalling instruments and their accessories. The company was established in 1880 and thus has an engineering and manufacturing experience extending over more than 40 years. This long service to the railways enables the company to produce apparatus adapted to its purposes, whose dependability is assured. The main office of the company is at Boston, Mass., and branches are maintained in New York City and Chicago.

Highway Crossing Signals

The United Electric Apparatus Company makes various types of highway crossing signals, the one shown in the illustration being the style D 1. The several types of crossing bells are of rugged construction and are designed to give efficient service. The Style D 10, enclosed type, and the Style D 11, open type, are each made in two sizes, 12 in. and 14 in. The Style D 12 is a waterproof bell and is made only in the 12-in. size. All bells are wound to any desired resistance. Tower or crossing bells, styles D 13 and D 14, are made in six sizes, 3 in., 4 in., 5 in., 6 in., 8 in., and 10 in. The standard size of the Cow Bell, style D 15, is 2½ in. by 4 in., and of the Tea Bell, style D 16, is 5 in., but other sizes may be supplied when desired.

Highway Crossing Signal Style D-1

The Ziegler Relays

The fact that the relay is one of the most important electrical devices used in signal work has been kept in mind during all the years of development of the Ziegler relays. While the effort of the United Electric Apparatus Company, maker of these relays, has been directed to the development and production of electrical instruments in general, special attention has been given to relays and kindred devices. The Bracket or Wall-Type Relay was originated by A. A. Ziegler, patents applied for in 1907-8 and granted 1916-18. Beware of infringers. They are manufactured by the corporation, and have proved a popular selection by signal engineers, and all relays can be constructed after this design. Relays can also be equipped with both bracket and base when required.

Neutral Relay—Style A-6 (Bracket Type)

While contacts can be furnished, composed of any of the materials ordinarily employed, the best results are obtained in low voltage work by using platinum to graphite for the front contacts and platinum to platinum for the back contacts. All required forms of contact may be supplied in any type of relay. Norway iron, subjected to a special annealing process, is used for the cores, pole pieces, back strap and armature. The relay magnets are wound to any resistance desired and all instruments are made in accordance with A. R. A. specifications. For certain kinds of work the open type relay is found satisfactory and it is supplied when required.

Neutral Relay—Style A-6 (Shelf Type)

The neutral relays are made with metal top or with porcelain top. The former is of government composition metal which has great strength and will not crack or alter its shape under the most adverse service conditions. The porcelain employed in the latter type is exceptionally strong, being specially adapted to this class of work. The polarized relay, which has metal top, is constructed in such a manner that a strong pressure is obtained on the contact fingers, supplying a reliable contact. The enclosed and open types of interlocking relays are designed to afford excellent service.

Alternating Current Relay—Style A-76

The Company makes as many as six different types of Automatic Time relays, some operating on local battery and some in the line circuit; also separate timing, devices, manual time elements and release devices.

Automatic Time Relay

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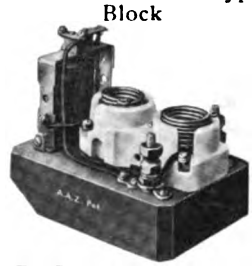
Automatic Cut-in Relay

The automatic cut-in relay used with electrically lighted signals is designed to obviate the need for two lamps being kept burning in the same signal. When a lamp fails from any cause the consequent opening of the circuit through it allows a contact to close, thus completing the circuit through the other lamp. The lamp blocks are made in many styles for D. C. or A. C. work and blocks for one or two lamps alone (without relay) and single-light focusing block and automatic double-light focusing block. Relays are furnished to be applied to existing installations.

All Electric Signal Lantern with C-6 Relay

Former Standard Type Block

Style C-6 Relay



R. S. A. Type Block

Indicators and Annunciators

The complete line of direct current and alternating current semaphore and disk indicators are designed along the same general lines as the Ziegler relays. They are furnished in either wood or iron cases either with or without contacts. The semaphore indicators are three positions, upper or lower quadrant. The disc indicators may be made to show any desired lettering on the face plate and disc.

Where drop annunciators answer the purpose, their use effects a saving over that of regular types of indicators and annunciators. They are made in two styles, the combined return and the separate return. The face plate and drops are lettered to suit requirements.

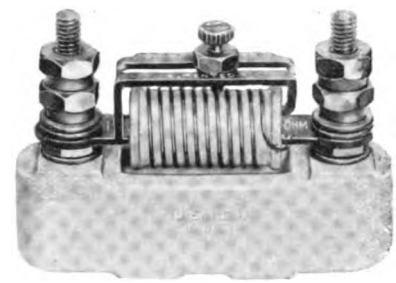
Indicator—Style B-2

Resistance Unit and Box

The testing instruments and resistances are wound to any resistance desired and the latter are of various types for attaching to a bus bar, to a fixed support or for use as an adjustable unit. The resistance units are wound on porcelain spools and mounted on glazed porcelain blocks. All coils are thoroughly varnished with several coats and baked. The variable resistance box, which will be found useful for testing, is of the portable enclosed type, and has a wide range of adjustment.

The terminals are made with wood, slate or other material for the base, with any number of terminals mounted upon it and in accordance with specifications or drawings. The terminal blocks are made in A. R. A. patterns and in two special designs, one with tag mounting long link and one with fuse and tag mounting.

The fuse blocks are similar to the resistance units but are provided with fuse clips for holding 250-volt, 0-30 amp., N. E. Code fuse, ½ in. by 2 in. The lightning arresters are made in several styles, with composition base, with serrated carbon strips on a slate base and with slate base with springs for holding copper or carbon blocks separated by perforated mica or other insulation.



Resistance Unit—Styles 20-S

Variable Resistance Box—Style H-11

Auxiliary Electric Devices

The varied line of products of the United Electric Apparatus Company includes keys and switches, testing instruments, resistance spools and units, both fixed and variable, terminals and terminal boards and blocks, fuse blocks and lightning arresters. The Rexlo Storage Battery Unit and the Rexlo D. C. Bell Ringer are also among United Electric Apparatus Company products. The keys and switches are substantially constructed and mounted on slate bases. The keys have front and back contact and the switches are single throw and double throw.

Strap Key—Style F-2

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BOND WIRE PROTECTOR

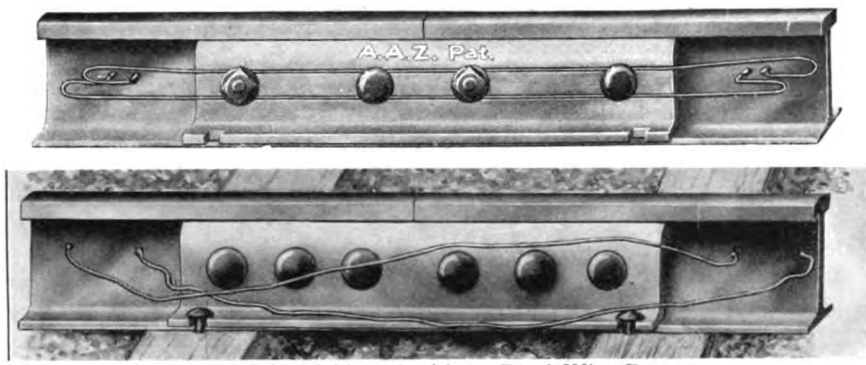
Bond Wire Protection 3 for 1

The liability of signals going to stop by reason of broken bond wires, thus causing unnecessary delay to traffic if not accident by the application of the brakes in emergency is well known to maintenance men. This condition is

Universal Bond Wire Protector

brought about most frequently by the breaking of the wires at their connections with the rails through repeated vibration from the jar of passing trains, or occasionally as a result of the wires being caught by dragging parts of cars.

The United Electric Apparatus Co., Boston, Mass., has developed a means of securing the bond wires in such a manner as to prevent failures from these causes while at the same time so protecting the bond wires throughout the entire length of the splice that trespassers or the trackmen cannot readily disturb them. This method requires no extra labor on the part of the track or signal forces, and furnishes positive protection without added attachments to the joint or any reduction in its strength.



Joints with and without Bond Wire Protector

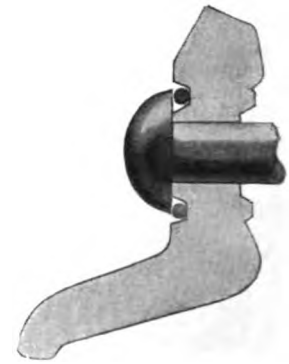
Universal Bond Wire Protector

The protection consists in rolling into the standard splice bar either two single grooves, or a single groove large enough to house both bond wires. In either case the groove is so located and of such size as to permit of the bond wire being slipped behind the bolt head washers or nuts, without loosening them, and is of sufficient depth to allow tightening of the bolts without injury to the wires. This device obviates the necessity of taking off the nuts in applying the bond wires and, besides saving this labor, avoids the possibility that the bolts will not be put back.

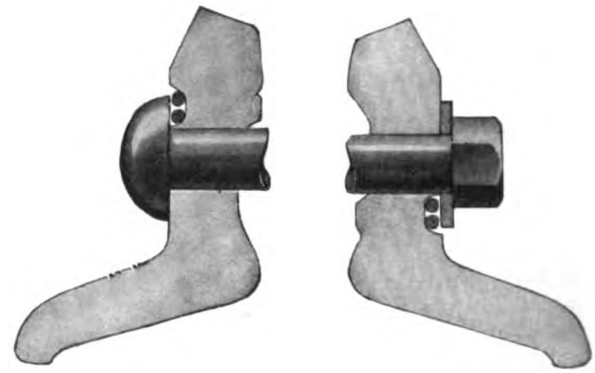
For plates not grooved and repair work the company furnishes the Style 2 and 2A forged grooved bolt head, which facilitates the application and retention of the bond wires, and also the Style 3 open bolt washer, to be applied by merely loosening the nut without removing it, and the Style 3A closed washer, which requires the removal of the bolt.

Special Advantages

The ability to apply the new bond wires without the aid of a wrench, which work is generally done by the signal department, eliminates a division of responsibility in the maintenance of the bolts and assures that they will not remain loose through this cause. The positive protection afforded by reason of the bond wire being shielded throughout the length of the joint, avoids bond wire failures by reducing the vibration to a minimum.



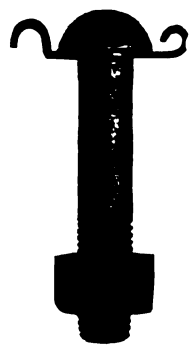
Section



Sections with Wires Above and Below

The untidy condition of unprotected bond wires detracts greatly from the appearance of otherwise well maintained tracks, besides interfering with the routine work of track repairs such as tightening bolts, tapping down spikes and, to some extent, tamping the joints. The Universal bond wire protector has established its place in maintenance as one of the smaller devices designed to perform an important service. It is of universal application because it may be employed with any kind of angle bar or rail joint.

Washers
Open Style 3
Closed Style 3-A



Regular Bolt
With Style 3-A
Washer

Bolt Heads
Grooved
Style 2 Square
Shoulder
Style 2-A Oval

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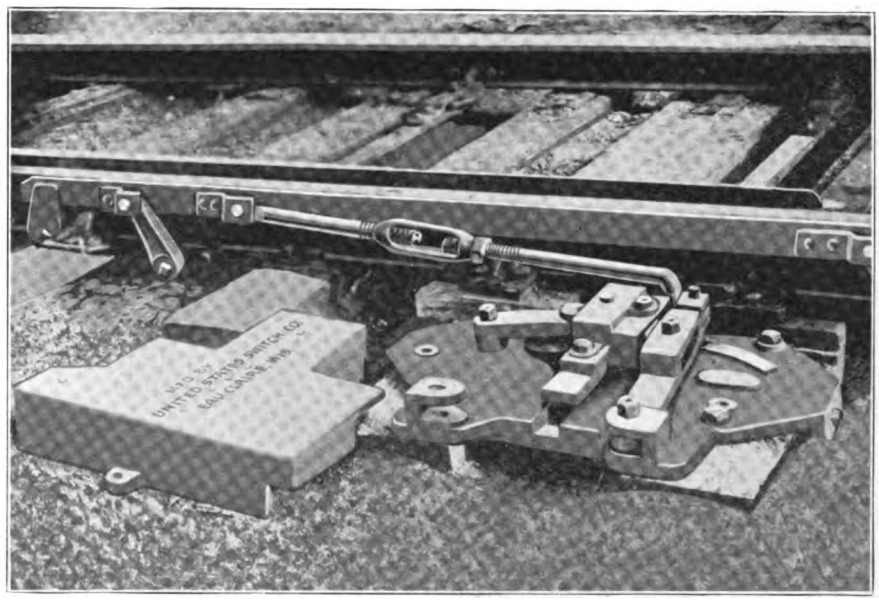
AUTOMATIC SWITCH LOCK

General

The split or point switch is nearly as old as the railroad itself, although its common use dates back no more than about three decades. From the earliest days the danger has been recognized of trains "splitting the points" when making a movement toward the switch or while passing over it, either through inopportune throwing of the switch, lack of adjustment or actual failure. The United States Switch Company, Eau Claire, Wis., has developed its automatic switch lock and safety device with the object of safeguarding the split switch and eliminating the possibility of derailment.

The correct functioning of the device is assured in the following particulars:

1. It prevents throwing a switch under a car or caboose.
2. It prevents taking the switch away from an approaching engine or train.
3. It closes and locks a switch not fully closed through carelessness or other cause.
4. It forces the switch point against the stock rail if the switch is out of adjustment.
5. It closes the switch even if disconnected from the switch stand.



Automatic Switch Lock Applied to Switch

The excellent wearing qualities of the device have been produced through the use of high grade steel castings or drop forgings, skilled workmanship in the manufacture and thorough inspection and test before installation. All the parts are made to jigs and templates and are guaranteed to be interchangeable.

United States Automatic Switch Lock

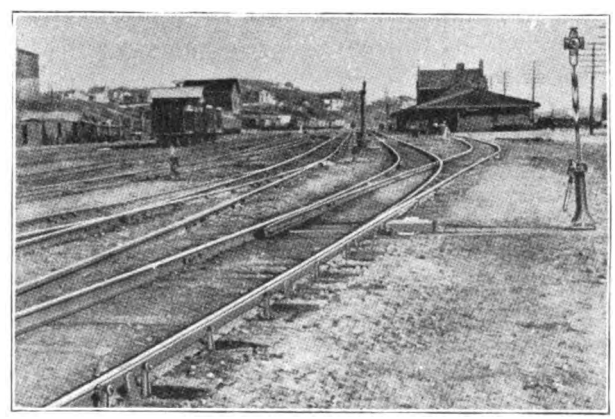
The essential features of the automatic switch lock are a locking bar, which is of the same general construction as a detector bar, and the locking device proper, which is carried on a heavy steel base plate attached to the head block ties, and which connects with the locking bar through an adjustable connecting rod and with the switch throw rod through a train of levers. The operation of opening or closing the switch raises the locking bar to a maximum height of 1⅛ in. above the top of the rail and lowers it again. The bar is always slightly elevated so that the passing wheels bring continual force to bear upon the switch point to keep it close against the stock rail.

The locking bar is carried on links which are always inclined toward the switch, so that the only effect of the wheels is to depress the bar and force it forward. The base plate has flanges extending downward which engage both sides of the two head block ties, preventing any possible lateral motion of the lock on the ties. The lever train is so arranged that a dead center is impossible. The device can be installed by two section men in less than a day.

Operation of The U. S. Switch Lock

When the wheels strike the end of the locking bar they cause the bar to move down and endwise, thereby creating a pull on the connecting rod which rotates the main link. Connecting with the main link is a short link which carries at its end a roller which in the central position engages with another roller, the single line of contact insuring that the levers will not remain on the dead center.

When the head rod has moved a slight distance off the center a large roller comes into action, taking up the side thrust or friction, and permitting the automatic lock to force the switch points to the closed position easily. The switch point is kept in close contact with the stock rail through the continued pressure exerted upon the locking rod by the passing wheels. This feature increases safety, especially where the main track point is on the high side of a curve.



Installation of Automatic Switch Lock

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General

In an announcement made in the early part of 1920 the Simmons-Boardman Publishing Company said "That the Simmons-Boardman Publishing Company may be more truly 'The House of Transportation', we will soon launch a 'Shipbuilding Unit' which will be a close companion to the Railway Unit, the first section to be known as the 'Shipbuilding Cyclopedia'."

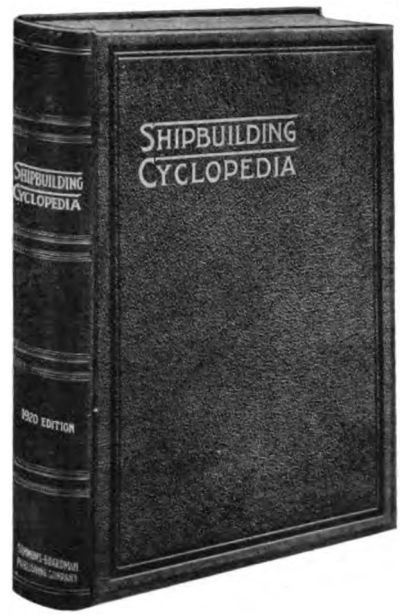
For many years the Simmons-Boardman Publishing Company has been giving indispensable service to the railway industry by the publication of the Railway Age, a general railway weekly, and four monthly magazines each devoted to a special branch of the railway field, together with a line of cyclopedias covering various railway departments. These publications comprise what has come to be known as the "Railway Unit" to which reference is made in the preceding quotation.

The Catalog Section is made up of valuable information regarding ship and shipyard equipment.

The compilation of the Shipbuilding Cyclopedia has necessarily entailed the getting together of a vast amount of material relating to every phase of the general subject; and this, as well as the knowledge acquired by the editorial staff in the preparation of the work, is at the disposal of manufacturers as a part of the service which "The House of Transportation" renders to the whole transportation world.

"Marine Engineering"

In the same manner in which the periodical publications of the Simmons-Boardman Publishing Company which are devoted to the railway interest supplement and are supplemented by its railway cyclopedias, its monthly marine publication, Marine Engineering, supplements and is supplemented by the Shipbuilding Cyclopedia. The relation of the two publications is on the one hand, that of the up-to-date collection and chronicle of matters of importance in the marine field, and on the other hand, that of their permanent preservation.



The Shipbuilding Cyclopedia

The Shipbuilding Cyclopedia is a reference book of over 1200 pages covering definitions of shipbuilding terms, basic design, hull specifications, planning and estimating, ship's rigging and cargo-handling gear, tables of displacement of commodities, arrangement and working drawings of modern vessels and a composite catalog of marine equipment. The volume is designed to present the basic reference requirements of the shipbuilding industry. Much of the design data included in the volume have never before been published in a simple form that can be readily used in the practical designing of ships. Various complicated problems of design and construction can be quickly determined by reference to its pages.

A further valuable feature, unique in this publication, is the inclusion of the only published collection of arrangement and working drawings of American ships, fully dimensioned and accompanied by bills of material. These drawings are types of the latest designs and many of them are susceptible of more or less standardization—a matter of importance in economy of construction.

Marine Engineering has for many years been a publication of high standing among the designers and builders of ships. The editors of the Shipbuilding Cyclopedia have been added to the staff of Marine Engineering, thereby maintaining the close relation of the two, and assuring the production of an engineering periodical, devoted to shipbuilding, which shall hold the same high rank in its field as the railway publications of the Simmons-Boardman Publishing Company have for many years held in the railway field.

The subscription price of Marine Engineering is $4.00 a year in the United States, Canada and Mexico; in foreign countries, $5.00 a year.

"The Boiler Maker", also a monthly publication, to which reference is made on another page, is devoted partly to the marine and partly to the railway field. It therefore forms to some extent a connecting link between the two sections of "The House of Transportation."

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MECHANICAL RECTIFIERS

General

While the Valley Electric Company makes a large variety of electric equipment, its products most directly applicable to the railways are the several types of mechanical rectifiers, designed specially for charging storage batteries from alternating current. The increased use of the storage battery in electrical signal systems has

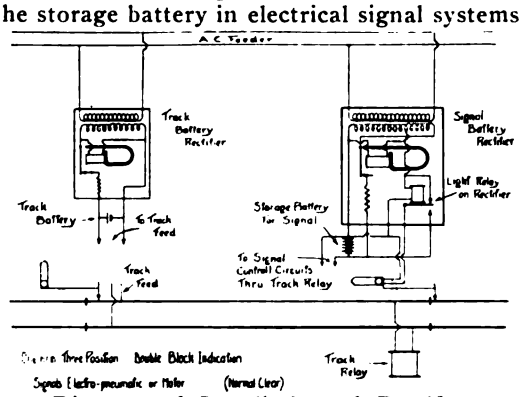


Diagram of Installation of Rectifiers

created a large demand for a charging system which is simple, dependable and inexpensive to operate or maintain. Any number of lead cells from 1 to 12 can be charged with the Valley rectifiers, which have now been in continuous operation on signal systems for three years without any replacements or renewals.

The effectiveness and simplicity of the Valley rectifiers have been fully demonstrated in service. As a single example of their economy in maintenance the Erie Railroad, with over 2,000 miles of block signals, which formerly charged its storage batteries from 500-volt stations about 15 miles apart and at a cost of $6 to $8 per kilowat hour, reduced this cost to between 30 cents and 40 cents per kilowat hour by the use of the Type MS rectifier. The Norfolk & Western test of the Valley rectifier showed that equipment might remain in use 1½ years without developing trouble. The Electric Storage Battery Company has adopted the Valley rectifiers for all installations made by that company.

The rectifiers supplied by the Valley Electric Company are guaranteed to be free from all mechanical and electrical defects for a period of one year. The transformers are built of the best silicon transformer sheet steel. The coils are made partially water proof, being heavily coated with varnish. The armature in all types is spring suspended and there are no pivots or parts to wear out. The contacts being of platinum irridium and free from sparking, their wear is negligible. A small fuse in circuit with the battery affords complete protection. The transformer taps are so arranged that any number of cells from 1 to 7 can be charged, the charge being adjusted by a resistance. Standard R. S. A. terminals and interchangeable charging resistances are used on all instruments. The terminals are marked plus and minus so that the battery may be connected properly. As the armature always remains "open circuited" when the alternating current is off, a battery will not discharge back through the rectifier if the alternating current should fail. The apparatus starts automatically when the supply source is resumed. Rectifiers can be furnished to operate from 110 volts to 440 volts, at 25 cycles to 60 cycles.

Valley Electric Type MS Rectifier

The Valley Electric Type MS Rectifier was the original type of mechanical rectifier which demonstrated practical results in charging the storage battery from alternating current supply lines. This type is still in use for general battery charging service, such as for track, signal operating and line batteries, but has been replaced in many railway services by the two more recent types described below.

Valley Electric Type RS Rectifier

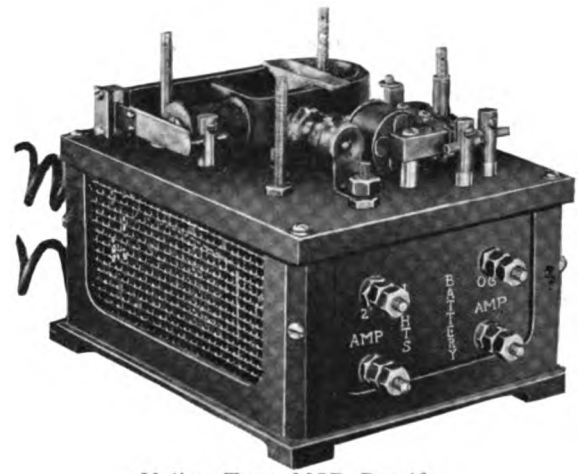
This is the type designed specially for railroad requirements and used where a definite number of battery cells have been made standard. It can be furnished for charging from 1 to 7 cells, but each connection is arranged for a fixed number of cells. In this type the moving element can be removed and replaced with another movement without breaking the seal or disturbing the connections.

As the type RS rectifier is arranged for a particular number of cells it has been made of small size, although neither ruggedness of construction nor reliability of operation has been sacrificed in any particular. It is more compact, convenient, and of higher efficiency than the older type of rectifier.

Valley Electric Type MSR Rectifier

This type is recommended where it is desired to electrify the signal lights in addition to the normal charging circuits. It is similar to the general service type of rectifier except that it has in addition a relay which acts as an automatic light switch. The relay is of rugged design and is extremely simple, consisting of few parts, and is positive in action. The four secondary terminals are arranged, two each for lights and battery circuit.

The lighting terminals are low voltage alternating current and come directly off the secondary side of



Valley Type MSR Rectifier

the rectifier transformer. The lights are normally energized from this transformer, which eliminates the loss of efficiency when the lights are energized from the battery. The relay only functions in case of an alternating current line failure and throws the lights onto the fully charged battery. With the return of the alternating current, the relay again connects the lights to this source.

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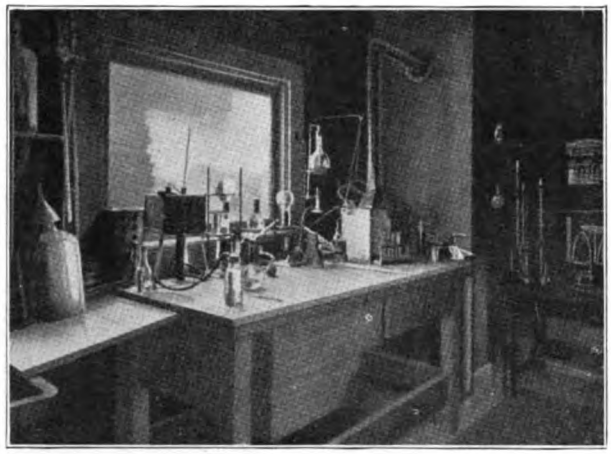
General

Since 1868 the Verona Tool Works have been known as manufacturers of track tools and nut locks of a peculiarly high standard. Uniform excellence of such products can only be maintained by a rigid running inspection of the finished product, coupled with definite knowledge of the qualities of the raw material, and to this end a system of physical and chemical inspection has been developed in the Verona plant that has practically eliminated the possibilities of service failure.

Besides a laboratory for analysis of incoming material, approved hardness and resistance testing machines are constantly operating on the finished product, keeping a permanent check on the "human element" and eliminating material which, under other conditions, might pass to the user as "good enough."



Laboratory of Verona Tool Works

The two Verona products, tools and nut locks, are important items in roadway and track maintenance. The aversion of labor toward using inferior tools is well known, and the provisions of workmen's compensation laws make the furnishing of safe material and tools an economic necessity. Personal injury has too frequently resulted from sudden failure of such articles and, from both a service and safety standpoint, too great care cannot be exercised in their selection.

From its organization the Verona Tool Works has realized that continued and profitable business relations can only be maintained by furnishing a product which meets the requirements of safety and economy in service, and has subordinated the question of "first cost" to the co-ordination of cost, lasting service and elimination of failure. An experience of 50 years has resulted in satisfaction to the actual user and a saving in renewals to the purchaser.

Verona Nut Locks

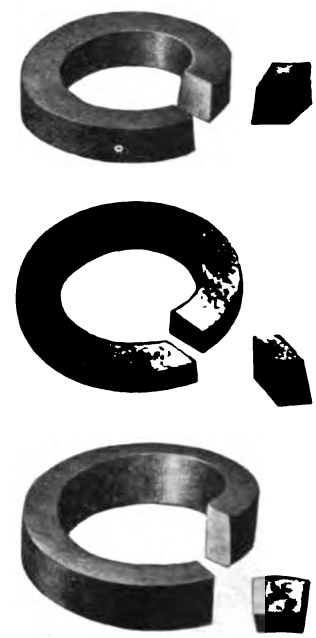
Nut locks are the almost universal means of keeping track joints tight between the visits of trackmen. Their detailed duty is to exert constantly the reactive force necessary for holding the splice bars in proper wedging contact with the rail, at the same time preventing bolt breakage and elongation by cushioning the bolts against the intermittent impacts of passing traffic.

The chemical specification of the American Railway Engineering Association for spiral spring nut locks merely requires that neither phosphorus nor sulphur content shall exceed .05. The formula for nut lock steel adopted by the Verona Tool Works is known as the Pennsylvania spring steel analysis, and is as follows:

Carbon	0.90—1.10
Manganese	0.35—0.50
Phosphorus	below .04
Sulphur	below .04

The uniform and permanent resilience of Verona nut locks has been attained by the use of steel of the above analysis, by scientific heat treatment in the forming, hardening and tempering processes, and by a uniform test of each finished piece. A footnote of the A. R. E. A. nut lock specification states that a true test of the device is the amount and durability of its reactionary power and Verona's long experience has shown that this is best obtained by the use of high carbon spring steel, formed hot prior to hardening and tempering. Over a billion Verona nut locks have been placed in railroad track service since 1875, a criterion of uniform excellence which requires no further comment.

The Verona Tool Works still furnish in considerable quantities the original pattern of nut lock coiled from a square bar ¼ in. by ¼ in. As coiling from a square or rectangular bar produces a finished product whose greatest thickness is next the bolt, most roads today specify a finished product of parallel faces in order to assure a better bearing for the nut. This is obtained by coiling a bar of keystone section, with the narrow end on the mandril, and the readjustment of area in forming produces the parallel faces of the finished nut locks.



Verona Nut Locks

The parallel nut locks most commonly in use are ⅜ in. by ¼ in. for ¾-in. and ⅞-in. bolts, and ⅜ in. by ⅜ in. for ⅞-in. bolts and larger. The ⅜-in. by ⅜-in. nut lock, which Verona has produced for 10 years, furnishes an extraordinary combination of durability and reactive force, while its parallel shape provides the desired frictional bearing between nut, nut lock, and splice bar.

Verona Track Tools

The productive labor of track and construction gangs varies in a considerable degree with the quality of tools used. Inferior tools mean inferior work, and the unwillingness of laborers to put forth their best efforts with tools of

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faulty and possibly unsafe design and of inferior material is well known. Every tool manufactured by the Verona Tool Works is either stamped VERONA in legible letters or bears the trade-mark shown, and there are few trackmen who do not recognize this trade-mark as standing for what is most desirable in a track tool.

Trade Mark

The section work necessitates an equipment of tamping picks, bars of various types, spike mauls, rail cutters, sledges, adzes, rail tongs and tie tongs, and the repairs around switch connections cannot be done conveniently without the use of the Verona spike puller and the Samson or Jim crow benders. Many other tools not indispensable are yet economical equipment for the section forces.

The Verona Tool Works manufacture practically every tool used in maintenance except shovels. The steel from which the tools are made is produced to a special specification and is purchased from standard steel-making concerns, which removes the possibility of inferior material going into the manufacture of Verona tools. All tools are inspected before and after each process is completed and any that show defects in heat treatment or in fabrication are rejected.

Tools are often redressed when not enough of the metal remains for economical repair. The Verona Tool Works is in a position to furnish blue prints showing the limit of wear for safe use and the stage at which the tool should be scrapped, together with detailed instructions relating to the manner of redressing tools.

Verona Tamping Picks

Probably the tool of most universal need in maintenance is the pick. It is generally of one of two kinds, the tamping pick or the clay pick. The tamping pick has either a V tamper end, a T tamper end, or a patented diamond tamper end on one side and on the other side a diamond point end for drawing sufficient ballast aside for tamping under the tie, or for pulling out old ties for renewals. The clay pick usually has one diamond point and one chisel point, but for grading operations both points generally are diamond point. The standard weight of the tamping pick is 7½ to 8 lb., and of the clay pick 6½ to 7 lb. The size of the eye in both the tamping and the clay pick is 2 in. by 3 in. The entire line of picks of the Verona Tool Works are made of the best grade of open hearth steel and are specially tempered.

Verona Clay Pick

Verona Tamping Pick

For greater durability of the pick when repaired, either in the supervisor's blacksmith shop or in the mechanical department shops, the works supply a tamping pick end of either V or T design which weighs 2½ lb. These may be applied to old tamping picks when worn to the limit for redressing or may be attached to the chisel end of a clay pick to change it into a tamping pick.

Verona Track Chisels

The track chisel is an indispensable tool in maintenance because of the frequency with which rails must be cut. For the best results there is necessary not only a correct design but a high quality of steel capable of taking the required temper without being made too hard. The latter condition results in quick failure of the cutting edge by pieces breaking off which endanger the eyes. If too soft the head soon brooms from the heavy blows of the striking hammer and this introduces a further danger to the eyes.

Verona Chisel Full Wedge

The Verona Tool Works makes a track chisel which has been established as standard both in design and quality of steel. The body of the Verona chisel is either the full wedge section or the doube hollow face, each of which has its advocates. The essential features are the design of the point and the temper. The Verona track chisels are made of special steel, heat treated, which will give excellent service until worn out, if properly redressed. The Verona Tool Works supply rules for redressing and tempering track chisels, together with suggestions for the proper use of chisels, which are based upon a careful study of these important matters. It may not be entirely understood, for example, that the use of a sledge in place of a spike maul for striking the chisel is not only a safer practice, but increases the life of the chisel.

Verona Track Wrenches

The track wrench is one of the most important in the list of track tools by reason of its constant use in laying new rail and maintaining existing track. Track bolts cannot be tightened to the proper degree without the use of a wrench specially designed for the particular purpose. Its length must be such that the trackman can without undue strain bring the proper tension on the bolt, and its jaws must so fit the nut as to reduce the chance of slipping and to bring lost movement to the minimum. Its material and treatment must be such as to minimize malformation in service, and the tool in general must be specially adapted to the particular track on which it is to be used.

The track wrenches made by the Verona Tool

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Works comprehend a variety of patterns, viz: The single end, with flat or round handle; the double end with straight or S-handle, which is essentially a section wrench, and especially one to be carried by the

Verona Track Wrench—Single End

Verona Track Wrench—Double End

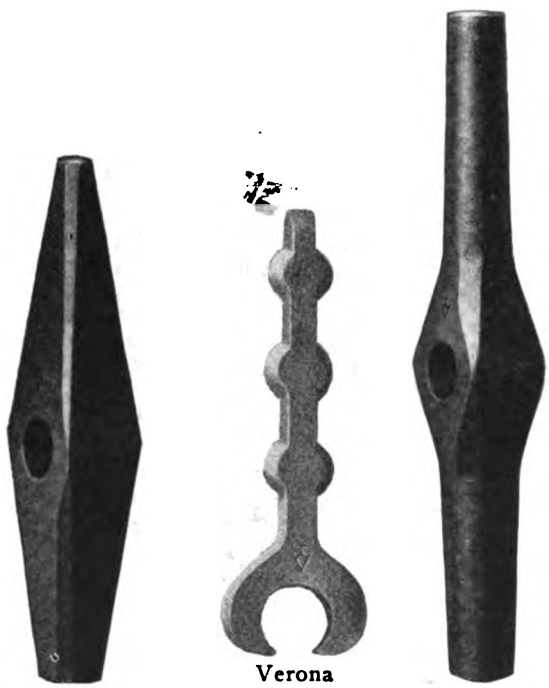
trackwalker; and alligator wrenches, required in the adjustments about switches and handy also in dropping the bottoms of hopper cars. The Verona Tool Works adds in all wrenches made by them the feature of carefully heat treating the jaws, which greatly decreases the liability of sudden fracture so often resulting in personal injury.

Spike Mauls and Claw Bars

In laying new track or gaging an existing track the spike maul is a primary consideration, while the claw bar is a necessary accessory. The Verona Tool Works furnish two leading designs of spike mauls of standard weights of 8, 9, or 10 lb. The No. 5 or bell pattern spike maul has two round faces, one standard and one small for spiking in close quarters. The No. 6 has two square beveled faces, one large, and one small.

The quality and design of the claw bar are important considerations, both from the standpoint of efficient work and for avoiding the personal injuries which result from the bar slipping or breaking at the point. The claw bar recommended by the Roadmasters' and Maintenance of Way Association is the long heel pattern with pinch top, weighing 30 lb. The Verona Tool Works supply these bars, and others of less general use in maintenance, in a quality of steel guaranteed to give service. The Verona spike puller with two or three knobs is used in conjunction with the claw bar for pulling spikes in guard rail flangeways and on bridges.

Verona Claw Bar



No. 6 Maul — Verona Spike Puller — Bell Maul

Verona Spike Mauls and Puller

Verona Railroad Adzes

The adze is a tool continually used by both track and bridge and building departments. The Verona Tool Works furnish a special railroad adze made with a clay pick eye, round pole end and a bit from 4 to 6 in. A full head adze with standard socket also is supplied, which has a bit of 3½ to 6 in. The adze preferred for carpentry work is the carpenters' half head 3½ to 5½ in. bit. The adzes manufactured by the Verona Tool Works are made of solid steel and are oil tempered.

Verona Railroad Adze

Half Head Adze

Full Head Adze

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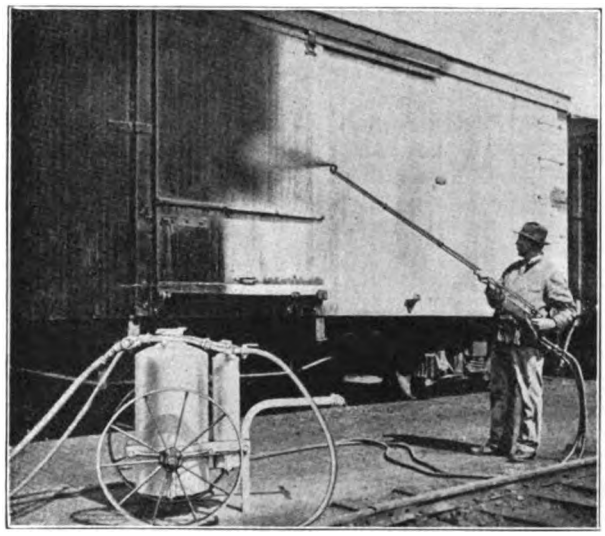
PAINTING MACHINE AND SAND DRYER

General

Harry Vissering & Company, Inc., Chicago, Ill., manufacture a variety of railway supplies and equipment, two of which, a paint spraying machine and sand drying apparatus, are of special application to the maintenance of way department. The first is employed by the bridge and building department, the second not infrequently by the track forces, since the drying of sand at outlying points sometimes devolves upon them.

The "Viloco" Portable Painting Machine

The economy of applying paint by the spraying process, especially upon flat surfaces and generally when scaffolding is required, is commanding live attention among maintenance officers. By many it is believed that three-fourths of the labor of painting with brushes and



"Viloco" Portable Painting Machine

one-fourth the quantity of paint can be saved by the use of a paint spraying apparatus.

The Viloco Portable Painting Machine is operated by compressed air with pressure varying from 60 to 100 lb., with a mean between the two extremes preferred. The paint tank is mounted on two wheels of 30-in. diameter and is of 26 gal. capacity. A 5-gal. tank for gasoline, used in freeing the paint line on occasion, is attached to the apparatus. The machine is compact in design and of strong and simple construction. It takes its compressed air from an existing main supply line and has a ⅜-in. air hose and paint hose connection to the paint gun.

The paint gun is strong and light and is therefore convenient for handling. It has pistol grip and control valve triggers which give the operator control over the air and paint supply at all times. The nozzle is so adjusted that a uniform spray is always maintained. The gun is 7 ft. in length, thus the operator does not inhale paint or fumes from the spray. The paint and air are delivered to the gun through two 50-ft. lengths of ⅜-in. hose.

The use of the paint sprayer when in the hands of a good operator results in covering the surface more quickly and also in reaching points which are inaccessible with brushes. With many machines there is a tendency for the paint to clog the line by drying in the hose and connections. This trouble is avoided in the Viloco Paint Sprayer through the three-way cock on top of the machine, which permits a small amount of gasoline to pass from the cleaning tank, thereby quickly relieving the line of obstruction.

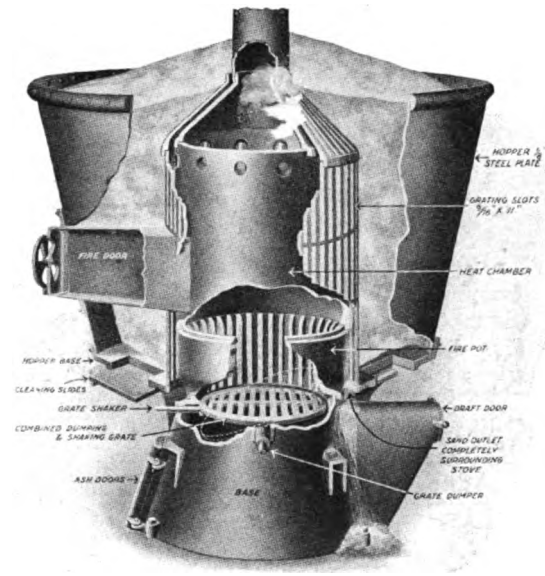
The "Viloco" Automatic Sand Dryer

The "Viloco" Automatic Sand Dryer is an apparatus manufactured for the purpose of drying sand. It comprises a combination stove and heat chamber surrounded by gratings and a 3 cu. yd. capacity steel sand hopper. The gratings prevent the sand from coming in contact with any part of the fire pot or heat chamber and permit it to filter through and drop to the floor about the base as soon as dry. During the drying process, the moisture extracted from the sand escapes through openings provided around the stack between the gratings and stove.

By preventing the wet sand from coming in contact with the stove the liability of burning out the stove is avoided, and by providing for the immediate removal of the dry sand from the heat of the stove, the possibility of burning the sand and thereby lessening its value for the desired purpose is also avoided. By means of cleaning slides provided in the hopper base, material that fails to pass through the cast iron grating may be removed readily without emptying the hopper by hand.

The fire door is outside the sand hopper, being carried on a casting extending through the hopper from the heat chamber, and the ash doors are made sufficiently large to permit the removal of the dumping and shaking grate through them without dismantling the dryer.

All parts are of substantial construction to insure



"Viloco" Sand Dryer

satisfactory service. The sand hopper, which is of ⅛-in. steel plate, is heavily reinforced at the top with a band of half round iron, and is rigidly supported on the base.

HARRY VISSERING & COMPANY, INC., CHICAGO

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General

The Warren Tool & Forge Company, Warren, Ohio, is the manufacturer of the "Quikwerk" line of railroad track tools. These tools are made of high-grade steel, generally with black finish, hammer forged where necessary, and with special attention to the tempering of the tools in every case. The steel is obtained in accordance with recognized formulae, and the processes of manufacture are watched closely to obtain the best in workmanship and finish. The design of the tools has been developed through extended co-operation with experienced railway men under whose direction the tools are used. The company is prepared to meet the wishes of the roads in variations from its standard designs and co-operates fully with railway officers in promoting the proper, safe and economical use of tools. While the company makes nearly every tool required in work on the railroad only those which may be classed as indispensable have been selected for detailed description.

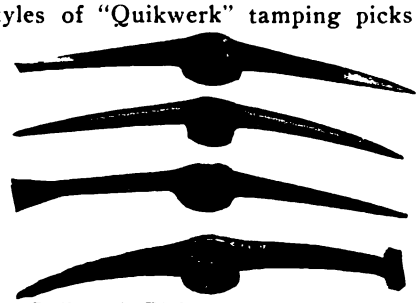
"Quikwerk" Railroad Picks

The railroad picks made by this company are of two types, the clay pick and the tamping pick. The No. 5, in the "Quikwerk" line, is the Railroad or Clay Pick, with a square point and a chisel end; and the No. 7, which is the perferred pattern for construction work, is made in three styles, with pencil points, with square points, and with point and chisel ends. These picks are made in the following sizes:

	The No. 5 Railroad or Clay Pick					
Weight	4 lb.	5 lb.	6 lb.	7 lb.	8 lb.	9 lb.	10 lb.
Length	21 in.	22 in.	23½ in.	24½ in.	25½ in.	26½ in.	27½ in.

	The No. 7 Construction Pick			The No. 10 or 11 Tamping Pick	
Weight	7 lb.	8 lb.	9 lb.	7 lb.	8 lb.
Length	29 in.	30 in.	31 in.	24 in.	25 in.

Of the two styles of "Quikwerk" tamping picks



Quikwerk Picks

the No. 10 has a "V" tamper end and the No. 11 a "T" tamping end. The entire line of "Quikwerk" picks is made of high-grade open hearth steel, hammer forged and correctly tampered. All are finished in black except the No. 5 which has polished points.

"Quikwerk" Railroad Adze

Another important unit in the "Quikwerk" line of tools is its Railroad Adze, which is forged from one piece of high carbon tool steel, and is finished in black except that the head and bevel are polished. The face of the head is hardened and the bit is tempered carefully. It has a solid punched eye to fit a standard pick handle. These adzes are made in weights of 4½, 5 and 5½ lb., in lengths of 10, 10½ and 11½ in. and with widths of cutting edges of 4, 4½ and 5 in. They are packed one dozen to a case. The "Quikwerk" line includes also the No. 20 pick mattock with adze and square point pick end, and the No. 22 long cutter mattock with the two cutting ends set at right angles with each other.

No. 19 Adze

No. 20 Pick Mattock

No. 22 Cutter Mattock

"Quikwerk" Bars

The bars used in track work require a high grade of steel in their manufacture, since they must have the maximum of strength without being of excessive weight. If there is frequent bending of the lining bar, work is delayed; a failure of the claw bar may cause accident; the hard use of the tamping bar, both its normal one and its occasional misuse for lifting, necessitate a good quality of tool.

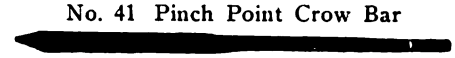
	The No. 42 Lining Bar					No. 43-B
Weight	16 lb.	18 lb.	20 lb.	22 lb.	24 lb.	30 lb.
Length	56 in.	60 in.	62 in.	64 in.	66 in.	5 ft. 2 in.
Diameter	1¼ in.	1¼ in.	1¼ in.	1 5/16 in.	1⅜ in.	1⅜ in.

	No. 43 Claw Bar with Heel					No. 43-A Bar
Weight	20 lb.	24 lb.	26 lb.	28 lb.	30 lb.	29 lb.
Length	4 ft. 6 in.	4 ft. 8 in.	4 ft. 10 in.	5 ft. 0 in.	5 ft. 2 in.	5 ft.
Square	1 3/16 in.	1⅝ in.	1⅝ in.	1¾ in.	1¾ in.	1¾ in.

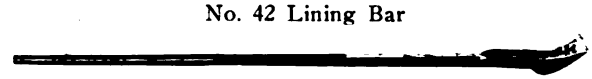
The No. 40 wedge point and the No. 41, pinch point crow bars, each used occasionally for lining track, and the No. 42, lining bar with round or diamond point, are made in all practical weights and lengths. The No. 43, claw bar with heel, No. 43-A without heel, and No. 43-B of the R. M. A. pattern, are made of forged steel with oil finish and with the claw specially tempered as a protection against sudden failure. The goose-neck bar and the shackle bar are also required for various uses.

No. 40 Wedge Point Crow Bar

No. 41 Pinch Point Crow Bar

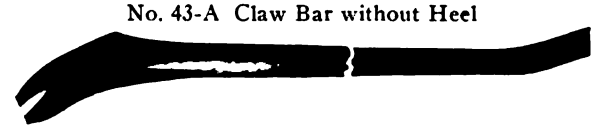


No. 42 Lining Bar



No. 43 Claw Bar with Heel

No. 43-A Claw Bar without Heel



No. 43-B Claw Bar, R. M. A.

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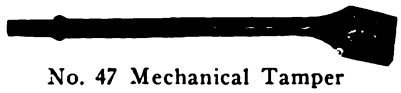
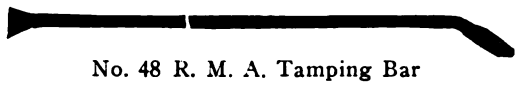
The "Quikwerk" Tamping Bars, of the No. 46, standard pattern, the No. 48, R. M. A. design, No.

	No. 46 Standard Tamping Bar			No. 47 for Mechanical Tamper	No. 48 R.M.A. Pattern
Weight	14 lb.	15 lb.	18 lb.	6 lb.	13 lb.
Length	62 in.	66 in.	72 in.	20½ in.	60 in.
Tamper	3½x3¾ in.	3½x3¾ in.	3½x7⅛ in.	3x⅝-¾ and ⅞ in.	4½x4½ in.

No. 46 Standard Tamping Bar

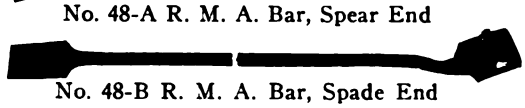


No. 47 Mechanical Tamper



No. 48 R. M. A. Tamping Bar

No. 48-A R. M. A. Bar, Spear End

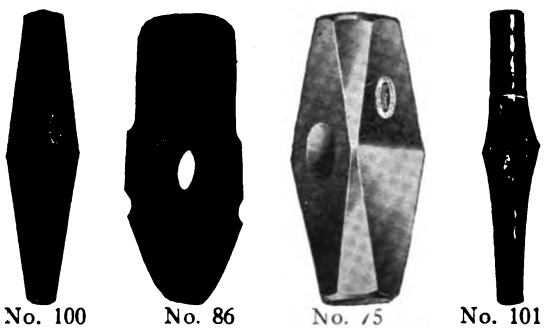


No. 48-B R. M. A. Bar, Spade End

48-A with spear end, and No. 48-B, with spade end, are made in the various lengths and weights shown in the table. Various other bars used in the bridge and building, signal and telegraph departments are also among the extensive "Quikwerk" line of maintenance tools.

"Quikwerk" Spike Mauls and Sledges

The "Quikwerk" spike mauls are made in two patterns, the standard and the Pittsburgh or bell pattern. The No. 100 standard spike maul, manufactured by the Warren Tool & Forge Company, is made in weights ranging between



No. 100 No. 86 No. 75 No. 101

Quikwerk Hammers and Sledges

5 lb. and 10 lb., the No. 101 Pittsburgh pattern in weights of 8 and 10 lb.

	No. 100 Standard Pattern Railroad Spike Maul			No. 101 Pittsburgh Pattern	
Weight	8 lb.	9 lb.	10 lb.	8 lb.	10 lb.
Length	12 in.	12 in.	12¾ in.	13⅛ in.	15¼ in.
Face Small	¾ in.	⅞ in.	1 in.	1-3/16 in.	1¼ in.
Face Large	1½ in.	1⅝ in.	1¾ in.	1½ in.	1⅝ in.

The No. 75, striking hammer, weighing about 10 lb., is the tool given preference for delivering the blow upon the head of the track chisel while in the heavier weights the striking hammer is much used for driving cross ties into place in respacing. The No. 84, double face blacksmith sledge, and the No. 86 straight pein blacksmith sledge are useful as auxiliary tools in track work, particularly the straight pein sledge.

QuiKwerK

The design of track chisel made by the Warren Tool & Forge Company has the correct contour of face, as well as of cutting edge, essential to good results in cutting rails along with safety in the operation. The design of the "Quikwerk" No. 160 Track Chisel having been developed through long experience, its shape should be approximated closely in the subsequent redressing of the tool.

	No. 160 Track Chisel				
Weight	4 lb.	4½ lb.	5 lb.	5½ lb.	6 lb.
Length	8¼ in.	8½ in.	9 in.	9¼ in.	9½ in.
Bit	1-3/16 in.	1-3/16 in.	1¼ in.	1¼ in.	1¼ in.

These track chisels are made of high carbon tool correctly tempered steel, and manufactured with

No. 160 Track Chisel

care in all essential details. The cutting chisels include also blacksmith chisels for hot and cold cutting, a splitting chisel and hand chipping chisels of various standard designs.

"Quikwerk" Rail Tongs and Tie Tongs

Rail tongs and tie tongs are among the "Quikwerk" tools of routine use in maintenance. The rail tongs weigh 18 lb. and open widely enough to accommodate a girder rail 6-in. wide. The tie tongs weigh 15 lb., measure 36 in. across the handles, and have a maximum opening of 1 ft., 7 in. The rail fork, a useful auxiliary tool in the handling of rails, is made with a solid steel slot and weighs 13 lb.

"Quikwerk" Wrenches

The track wrenches made by the Warren Tool and Forge Company are forged from special high-grade steel with the points hardened to prevent undue wear. They are made for all standard sizes of nuts and in lengths of 26 in., 28 in. and 30 in. They are of three patterns: No.

No. 153 Single End Track Wrench

No. 154 Double End Track Wrench

153, a single end wrench; No. 154, a double end wrench, the details of which are given in the table.

	No. 153 and 154 Track Wrenches		
Weight	5½ lb.	6½ lb.	8½ lb.
Length	26 in.	28 in.	30 in.
Opening	1-5/16 in.	1½ in.	1-11/16 in.
Size, Bolt	¾ in.	⅞ in.	1 in.

The Warren Tool & Forge Company also makes a large variety of other tools of occasional use on the track or in the maintenance-of-way blacksmith shop, such as track punches, B. S. round and square punches, backing out punches, carpenter bars, concrete, stone and coal picks, mason hammers, hoes, blacksmith vises and hammers, wedges, etc. They issue a complete catalogue giving full details of all tools.

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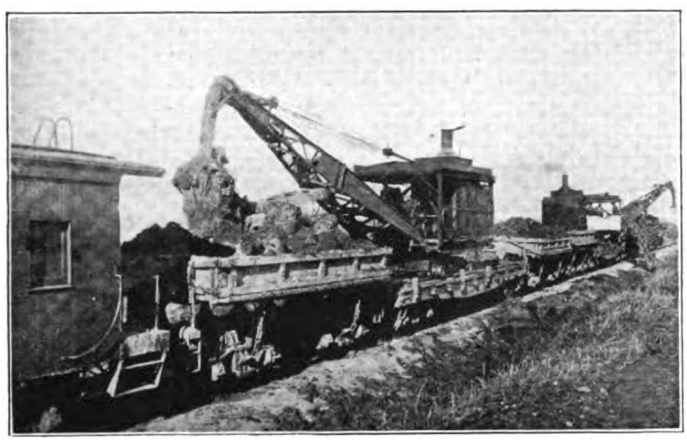
General

A manufacturing experience of more than 40 years has enabled the Western Wheeled Scraper Company to produce equipment adapted to the needs of the railways, especially in the maintenance-of-way department. From the original wheeled scraper which this company designed back in 1877, the Western line of earth-and-stone-handling equipment has expanded, until it now includes dump cars and spreader cars for levelling the fill; dump wagons; elevating graders; blade graders; rock crushers; wheeled, drag and fresno scrapers; plows for railroad and highway work, and other similar equipment.

The chief specialty of the company is its large air dump car, which has proved almost indispensable in modern railway construction and maintenance, having brought about a much desired saving in time, money and labor when used in ditching, filling trestles and similar maintenance work. Railway maintenance men today are agreed that great economy can be effected by an equipment of side-dump cars in ditching and construction service.

General Construction Features

The Western Air Dump Car, the first of the air dump cars having a tilting bed, was designed by the Western Wheeled Scraper Company for use in Panama Canal construction work. These original air dump cars are still in active service, but the design of the newer



Ditching with Western Dump Cars

cars has been improved and developed until the latest Western patterns may be considered models of superior air-dump-car construction. They have large dumping power, with much less consumption of air than other types of air dump cars.

They are built of the best materials obtainable; in 12-yd., 16-yd., 20-yd., 25-yd., 30-yd. and 45-yd. sizes; with vertical air cylinders; with M. C. B. construction throughout; with the familiar side chains for holding the bed in place, when desired; or without side chains, the bed being held in place by compression locks, automatically controlled; these composing a car which is capable of high-speed operation over long distances. The larger sizes have come into prominence on the railroads through the resulting economy when transporting loads in regular traffic movement. Western dump cars have been designed to meet all requirements of railroad ditching, grading, trestle-filling, the stripping of gravel pits, etc. The 12-yard size is built for either hand-dumping or

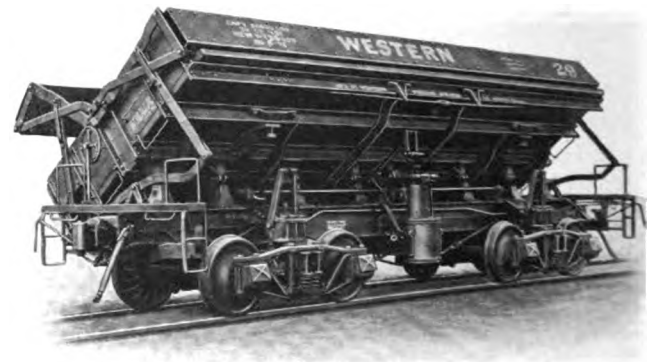
Western 30-Yd. Air Dump Car

air-dumping, as desired. The larger sizes, dumped by air, afford facilities for the transportation of maintenance bulk materials, thus enabling railroads to keep their traffic cars in revenue-producing service.

Special Features of Western Cars

Western cars are made with wooden bed or all steel, and of the best mechanical design and workmanship. The door arms, where they attach to the door and the bed, are pivoted in such a manner that as the bed is tilted the door is thrust outward and upward from the load, so that no part of the load, as it moves, is thrown against the door. This removes the tendency to derailment of the car by impact, to which cars lacking this construction are subject. When the bed is dumped, the door is brought to a position nearly parallel with the bottom of the bed; and this feature, by reason of the large discharge opening along with the acute angle of dumping, insures that almost anything which can be loaded into the cars will clear the side-board in dumping. The Western car is built as low as possible to maintain a sufficiently steep dumping angle. The capacity of the trucks is 100,000 lb. for the 30-yd. and 25-yd. sizes, and 80,000 lb. for the 20-yd. size.

There is a three-way valve on each side of the Western car, with a special safety feature which eliminates danger from leaky valves. A single operating lever



Western 20-Yd. Air Dump Car

connects both control valves and, the bed dumps in whichever direction the lever is pulled, the opera-

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tions of dumping and righting the car being practically instantaneous.

Western Spreader Car

Almost the entire cost of unloading ordinary service cars by hand-shoveling is saved by the use of Western air dump cars. The records of a prominent railroad show that the cost of handling material by flat cars and unloading plows is double, and the cost of operating the old-style A-frame side-dump cars is 25 per cent greater than the cost with Western air dump cars. Western air dump cars can be dumped while the train is in motion and can be dumped on a curve. They will be found valuable in winter for removing snow from railroad yards and stations. Since the cars can be run at high speed with safety they may be used for shipping materials from one point to another.

Filling a Trestle

Unloading Material from Western Cars

The Western Spreader Car illustrated is useful equipment for leveling the dirt unloaded from Western dump cars and has many auxiliary uses in maintenance, particularly that of clearing the road of snow in winter. The spreader is equipped with two main blades and two auxiliary wings on the front end for keeping the rail clean. The main blades can be used on both sides simultaneously or on one side only.

The width of cut may be narrowed and the depth of the cut regulated as desired. When it is necessary to pass trains the braces can be removed quickly and the blade swung back against the car. Material may be spread perfectly level, the adjustments being rapidly performed.

Other Grading Equipment

Western wheeled scrapers and drag scrapers are of frequent use in grading for additional tracks, and the varied line of railroad plows is a necessary adjunct of this method of grading. The powerful Western locomotive plow,

Western Rocker Dump Car

attached to an arm projecting from the work-train equipment, on either or both sides, is designed for ditching along the tracks, particularly in hard material, or where horses can not be used safely. As part of its grading service the company builds the Studebaker model of dump wagon, as well as the standard Western patterns in this line.

Maintenance ditching by the use of small dump cars, moved on a 24-inch gage light railway has been established as economical in many instances. The Western V-shaped steel dump cars, of 1½-cu. yd. capacity, are useful equipment for this purpose. The company also furnishes the portable sections of light railway required in this method, together with the necessary turnouts.

The main office and factory of the Western Wheeled Scraper Company are at Aurora, Ill. Branch offices are maintained in New York City; Chicago; Atlanta, Ga.; Dallas, Tex.; Denver, Colo.; St. Louis and Kansas City, Mo.; Memphis, Tenn.; Omaha, Neb.; Pittsburgh, Pa.; San Francisco, Calif.; and St. Paul, Minn. The company also is represented in many foreign countries throughout the world.

WESTERN WHEELED SCRAPER COMPANY, AURORA, ILL.

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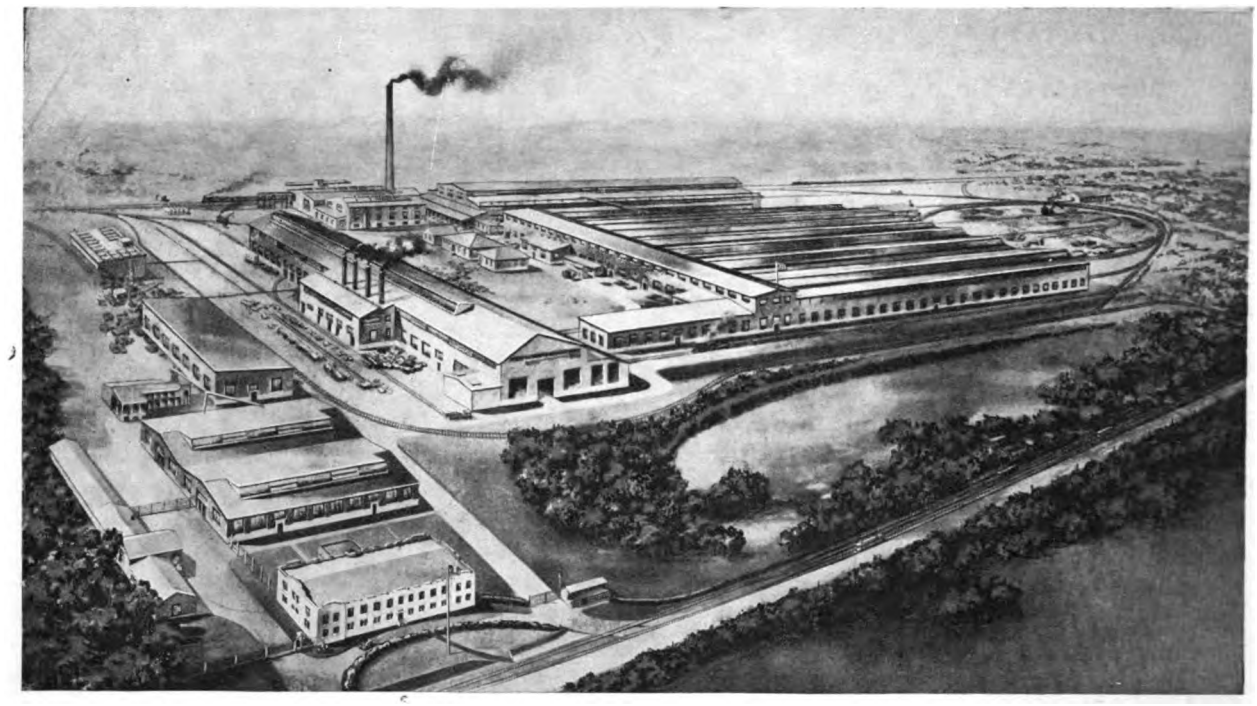
General

The business of William Wharton Jr. & Co., Inc., was founded by William Wharton, Jr., about 1859. Mr. Wharton was then already quite well known to the railroad engineers as the inventor of the Wharton Unbroken Main Line Switch, which was a radical departure from switches then in use, and is still in successful use, in a somewhat improved shape, under certain conditions on a number of railroads of the country. It was manufactured by the Wharton Railroad Switch Company, with which company Mr. Wharton was identified.

The Wharton Company obtained the manganese steel castings for its trackwork structures under an exclusive arrangement with the Taylor Iron & Steel Company, of High Bridge, N. J., who had the sole right for its manufacture in the United States from the inventor of manganese steel, Sir Robert A. Hadfield, of Sheffield, England.

The close relations, resulting from these operations, between the Taylor Co. and the Wharton Co., resulted in 1912 in the consolidation of these companies, the Taylor Company having its name changed to the Taylor-Wharton Iron & Steel Co., and the William Wharton Jr. & Co., Inc., becoming a subsidiary thereof. Other subsidaries are the Philadelphia Roll & Machine Co., and the Tioga Steel & Iron Co., of Philadelphia, Pa.



Plant of William Wharton Jr. & Co., Inc., Easton, Pa., situated on 100-acre tract; plant occupies about 30 acres, having 10 acres of floor space under roof.

Mr. Wharton was also a pioneer builder of, and maker of special trackwork for, street railways. Further, he was the inventor of another radical departure—the rolled grooved girder rails for street railway curves. In 1881 Mr. Wharton formed the William Wharton Jr. & Co., Ltd., with a plant in Philadelphia, Pa., for the manufacture of street railway special trackwork. In 1886 the company was incorporated, and in 1898 the Wharton Railroad Switch Works, with its plant in Jenkintown, Pa., was absorbed by the William Wharton Jr. & Co., Inc.

In many of the important improvements in railway trackwork the Wharton Company stands as pioneer. It is the originator of the use of manganese steel in tracks—first in street railway trackwork in 1894, followed by the introduction of manganese steel frogs and crossings on steam railroads in 1900. The superior merits of manganese steel in track structures, through its toughness and wear-resisting qualities, are now recognized all over the world. Most of the designs of manganese steel track structures now in use are based upon designs originated by the Wharton Company.

The greatly enlarged business had outgrown the plants at Philadelphia and Jenkintown, and in 1914 to 1915 an entirely new modern plant was erected at Easton, Pa., the same being situated on a tract of land containing nearly 100 acres, of which 30 acres, with floor space under roof of about 10 acres, is almost entirely devoted to the manufacture of track special work for both steam railroads and street railways.

Products

The Taylor-Wharton Plant at High Bridge, N. J., is devoted entirely to the making of manganese steel castings for various applications; such as in dredge work, steam shovel work, mine equipment, cement mill equipment, stone crushers, manganese steel safes, etc., and all the manganese steel castings for trackwork of the William Wharton Jr. & Co. Inc. are made there. The castings are made and treated by the Taylor-Hadfield process and are known under the trade-

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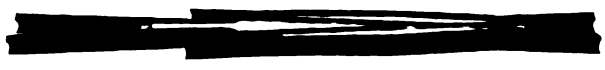
name of "TISCO" Manganese steel. In October, 1917, the 25th anniversary of the first making of manganese steel in America by the Taylor-Wharton Co. was celebrated, together with the 175th anniversary of the founding of that plant as an iron industry in America.

"Pennsylvania Limited" passing over Wharton Manganese Steel Rail-bound Frog near Berwyn, Pa.

The William Wharton Jr. & Co., Inc. plant at Easton, besides the trackwork, which is its main product, manufactures steel castings of converter and of electric steel, steel and iron forgings, and seamless steel gas cylinders, the latter being an outcome of the forging of shells which had become one of the products of the plant during the late world war.

Manganese Steel in Trackwork

The reliability and the great economy of properly treated manganese steel in track structures under the most severe traffic conditions has been proved beyond any doubt. The Wharton Co.'s manganese steel trackwork has many phenomenal records. The first solid manganese steel frog placed in the tracks of the Pennsylvania R. R. Broad St. Station, Philadelphia, in 1900 outlasted nearly 17 ordinary rail frogs, and after being reground to surface, gave another term of service, making a total of 25 times the life of a Bessemer steel rail frog. Railbound manganese steel frogs, which the Company originated, were in service for 14 years on the Main Line of the Pennsylvania R. R., between Philadelphia and Washington. Railbound crossings at the important junction at Dillerville, Pa., installed in 1902, were in service for 12 years. Many other examples could be given, and records of 8 to 10 times the life of ordinary rail frogs are quite frequent.

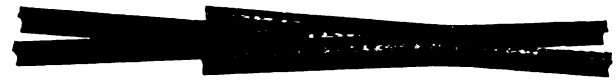


A. R. E. A. Standard Manganese Steel Rail-Bound Frog.

Bolted Rigid and Manganese Frogs

William Wharton Jr. & Co., Inc., manufacture the ordinary designs of stiff or rigid frogs of the filled and bolted types. Their specialty, however, is manganese frogs.

The solid manganese frog is a solid casting, made in such lengths that it can be joined directly to full-section rails with regular angle bars. The railbound manganese steel frogs have in a single piece the wings, point and heel blocks, which con-



A. R. E. A. Standard Bolted Rigid Frog.

struction is commonly known as the "center," and this is bound in by rails reinforced and jointed by heavy filler blocks.

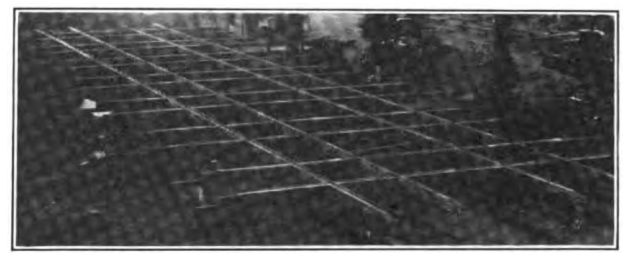
Unless otherwise specified, the bolted rigid frogs, as well as the manganese steel frogs, are furnished according to the designs adopted by the American Railway Engineering Association in 1920.

Spring Rail Frogs

Spring rail frogs are made to the standard designs of the individual railroads, or according to A. R. E. A. designs. The company also supplies manganese spring rail frogs designed to suit special conditions of traffic, in all patterns of which the point, wing reinforcement and heel block are combined in one solid manganese steel casting. The spring rail is reinforced with a manganese steel facing along the flange side, or is formed of a manganese steel casting hinged to the main casting.

Bolted and Manganese Steel Crossings

William Wharton Jr. & Co., Inc. supply plain bolted crossings and the manganese steel type of crossings. The latter are made in various designs of solid manganese steel and manganese steel center construction. The manganese steel crossing is particularly adapted for main line service, where the life of the crossing frequently may be ex-



14 Solid Manganese Steel Crossings—C. R. R. of N. J. over L. V. R. R. at Philips St., Jersey City, N. J.

tended to more years than formerly were measured in months. This type of crossing has not only proved economical by reason of long life and low maintenance, but it is also preferred because of its smooth riding and high factor of safety.

Movable Point Crossings

Movable Point Crossings are desirable for smooth riding and safety in many main line locations where interlocking mechanisms facilitate their operation, and they are essential for safety in plain crossings or slip switch cross-

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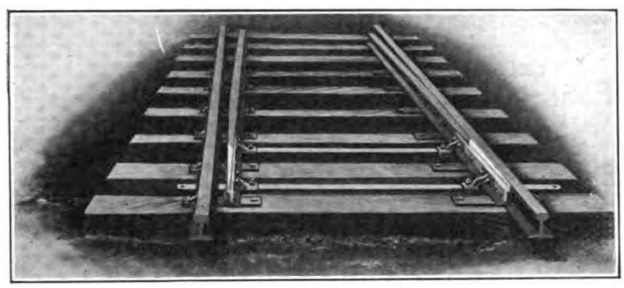
ings of low angle. The excessive wear on the points and on the stock or knuckle rails led to the introduction by William Wharton Jr. & Co., Inc., of manganese steel into these parts. In some cases it is preferred to make only the points of manganese steel, and in other cases only the knuckle rails; but the use of the hardened metal for both is advocated, as the wear on both the points and stock rails is usually equally severe, and should therefore have the protection of manganese steel.

Split Switches

The A. R. E. A. has adopted standard designs for switches in lengths of 11 ft., 16 ft. 6 in., 22 ft. and 30 ft. William Wharton Jr. & Co., Inc., recommend the ordering of switches of standard designs, but are also prepared to furnish them of any construction desired, both plain and with manganese points.

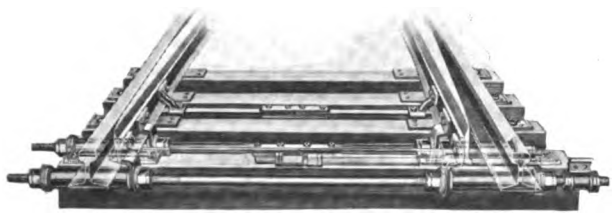


Manganese Steel Point Split Switch A. R. E. A. Standard.

The manganese point split switch is coming into greater use, not only in main track but also in switching ladders in heavy terminals. William Wharton Jr. & Co., Inc. make them with Tisco manganese steel points attached to the main rolled point and with Tisco manganese steel throughout the point. The greatest length of point supplied of the latter construction is 11 ft.

Switch Fixtures

The switch fixtures, such as rods, plates, braces, etc., are made in many different patterns to suit all the varied requirements of the roads. All standard fixtures adopted by A. R. E. A. are furnished. Particular attention is drawn to the Wharton-O'Brien insulated and adjustable switch rod and lock rod which are standard on several large roads for use in slip switches and movable point crossings, as well as in single split switches.



Wharton-O'Brien Insulated and Adjustable Switch Rods

The simplicity of connecting several switches on the same switch rod and lock rod and the ease of making adjustments and thorough insulation have proved of particular advantage. Multiplicity of rods and the consequent need of frequent attention by the maintenance department, are practically eliminated by the use of the Wharton-O'Brien rods.

The Wharton Switch

The name "Wharton" in connection with railroad track work first came into notice through the invention and introduction of the Wharton unbroken-main-line switch, which is adapted to siding connections and derailing switches. This type of switch has the advantages of safety, in that there is no splitting of points, and of economy, because the main-line traffic throws no wear upon the switch.

The Wharton switch is supplied with or without the feature of the automatic trip rail, by which a train trailing the switch set wrong throws it to its correct position. In the improved design, the switch rail is extended at the point end, making it unnecessary to use a separate guard rail in front of the point.

Guard Rail Clamps

William Wharton Jr. & Co., Inc. include among their specialties manganese guard rails and adjustable guard rail clamps. The clamp yoke is forged and combines strength with simplicity and holding power. This type of clamp avoids the need of a fitting piece through the yoke, being made to fit directly into the fishing section of the guard rail. It has been the standard clamp of the Wharton Co. for nearly 30 years, and has been supplied to railroads all over the country, Mexico, and Canada in large quantities.

Wharton Improved Forged Adjustable Guard Rail Clamp.

Tongue Switches and Mates

For tracks in paved city streets, where split switches cannot be used, the company has several designs of double tongue switches or tongue switches and mates, in either standard bolted tee rail construction, girder rail construction, or of solid manganese steel castings. The tongues are of manganese steel with substantial pivots, all ground to close fit and surface. Special throwing devices for the tongues, in cast iron boxes, with covers, are usually furnished with such tongue switches.

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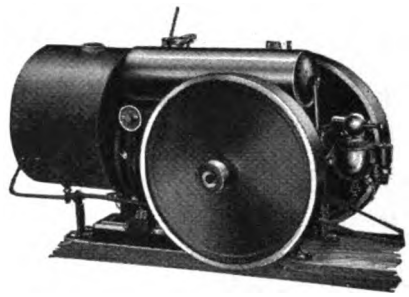
General

The Woolery Machine Company, Minneapolis, Minn., manufactures gasoline engines of 5, 7½, 10, and 15 h. p. for use on section, bridge, extra gang, and inspection cars. The engines are the product of a comparatively recent development and are designed especially for use in changing over hand cars or for replacing equipment already installed on these cars. The company also manufacturers complete motor cars with these engines already set up for immediate use.

The Woolery 5 and 7½ H. P. Engines

The 5 and 7½ h. p. engines are designed especially for use on the class of cars ordinarily employed on regular section maintenance work. They consist essentially of a two-cycle, reversible, water-cooled engine, mounted on an adjustable sliding base, equipped with battery or mag-



Woolery 5 and 7½ H. P. Engine

neto ignition, and having a one-lever speed control. The construction throughout is durable and at the same time light in weight, a 5 h. p. outfit, including engine pulley, starting crank, and oiling accessories, weighing only 180 lb., by reason of which one man can handle the car in taking it off the track or replacing it.

The engines are of the long stroke type with extra long piston; the construction, by reason of the large leverage secured and the liberal bearing surface in the cylinder, enabling the car to pick up speed rapidly, on the one hand, and on the other, by reducing wear, both prolonging the ordinary life of the cylinder and minimizing loss of power from poor compression. The 5 h. p. engine is capable of starting a ton load from a dead stop without assistance, and by brake test develops nearly 7 h. p.

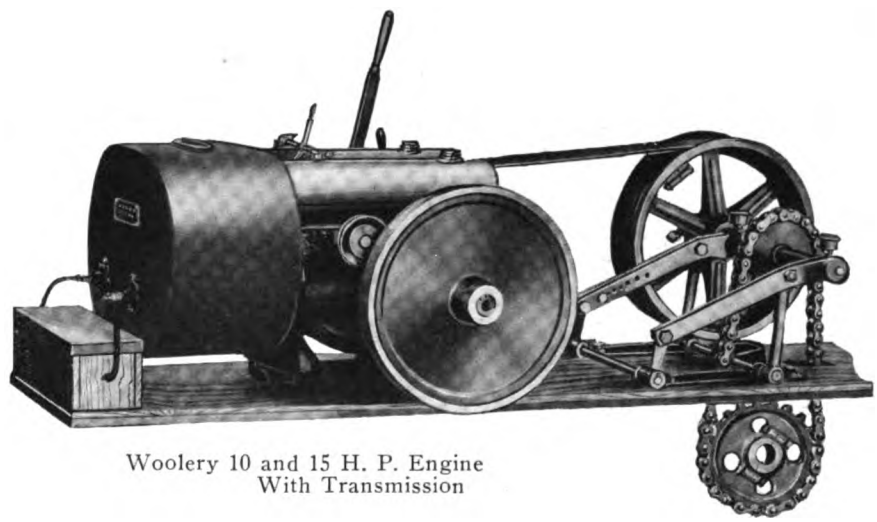
The connecting rod and crank shaft of each engine are of hollow steel, this construction affording ample strength and stiffness and at the same time contributing largely to the light weight of the engines. Both ends of each connecting rod are fitted with durable replaceable bearings. As a safety precaution, all engines have the marine type, spokeless, fly wheels, and for the purpose of simplifying repair work and expediting service, all like parts of all Woolery engines are interchangeable. The engines are made with plain or ball bearings as desired.

Each cylinder head is hemispherical with a small hemispherical chamber for the spark plug to insure regular ignition of small charges when the engine is running free or pulling light loads. By reason of this feature, in common with others, the Woolery engines can be relied upon to operate under unfavorable climatic conditions, particularly cold weather, the engines having made commendable records in service in this respect. The water jacket is cylindrical in shape and of welded steel construction. It is low and of large capacity, amply strong not to crack under the force of freezing water, and is easily removed, the last feature being distinctly of advantage in regions of hard water where frequent cleaning is advisable. The adjustable sliding base provides a stable support for the engine and yet permits starting it while the car is standing still, allowing it to run while the car is temporarily stopped, or of effecting a quick reverse while the car is in motion. The lever for shifting the engine is released simply by pressing a plunger in the lever handle and is accessible from any angle.

The single lever on the gasoline tank controls both the throttle and the battery switch. With it the car speed can be set at any point between 5 and 30 miles per hour. The carburetor is of the high grade float feed type and is in such arrangement with the gasoline tank and engine hand plate as to be easily removed either with them or alone.

The Woolery 10 and 15 H. P. Engines

The 10 and 15 h. p. Woolery engines are intended particularly for use on cars employed for bridge and extra gang work. They are identical in design and workmanship to the 5 and 7½ h. p. engines, except in having a twin engine, a rigid base, and employing a special transmission by means of which the greater power of the



Woolery 10 and 15 H. P. Engine
With Transmission

engines can be utilized more advantageously than by direct belt drive. In these machines the belt is tightened or loosened by shifting the countershaft.

The 10 h. p. Engine weighs 240 lbs. As they are equipped with a mechanical governor, both engines are well adapted to running a track tool dynamo or air compressor.

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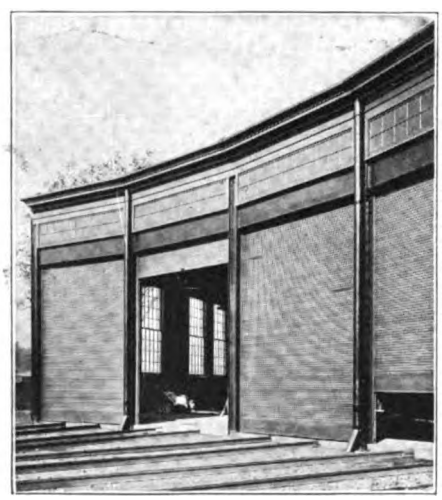
ROLLING WOOD DOORS

General

The determination of the type of door best adapted to close the wider openings in buildings necessary to railway operation, such as freight houses and roundhouses, has received an increasing amount of attention from engineers in recent years, the freight house being one of the subjects now being considered by the committee on Buildings of the American Railway Engineering Association. In the case of freight houses the doors are depended upon for a protection against both burglary and fire. The roundhouse door is subject to frequent damage unless built of proper design, and the safety of employees is largely concerned in the clearances afforded.

The J. G. Wilson Corporation, main office 8 W. 40th St., New York City, factories Norfolk, Va., has been specializing in the design and construction of rolling steel doors, rolling wood doors and fire doors for elevator and staircase openings since 1876. Its doors, shutters and partitions are made of iron, steel, and wood, and designs are available for every practical purpose in building construction. Its more than 45 years of experience are at the service of the railroads for the economical employment of its products, and the engineering bureau of the company is prepared to cooperate fully with the roads in the selection of the type best adapted to a particular situation.

The rolling steel door is accepted as the standard type for closing openings at many freight houses; the wood rolling door, on account of the deterioration suffered by steel doors from sulphur fumes, is a preferred type for roundhouses. The J. G. Wilson Corporation offers conclusive reasons for these selections which are embodied in the descriptions of the several types of doors and shutters.

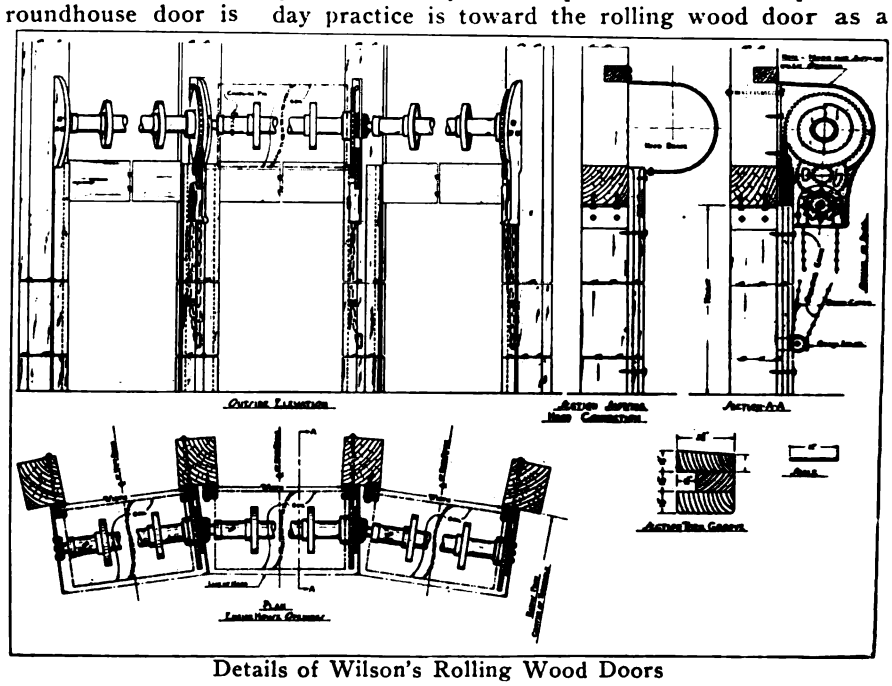


Wilson's Interlocking Slat Style 4

The Corporation has branch offices at Chicago; Philadelphia and Pittsburgh, Pa.; Atlanta, Ga.; and Los Angeles, Calif. Its factories are located at Norfolk, Va.

Rolling Wood Doors

On account of the corrosive influence of sulphur fumes in roundhouses the metal door is practically eliminated. Sliding doors are also not practicable, as they take up too much space. While wood swinging doors have been used quite commonly in the past, the trend of present day practice is toward the rolling wood door as a solution of many of the troubles pertaining to the older type. The frequent destruction of the swinging door by accidents makes its maintenance both troublesome and expensive. The narrowing clearance of this type from the face of the roundhouse to its outer ends introduces a very serious cause of personal injury. The alternative of greater distance of the house from the turntable is seldom practicable.



Details of Wilson's Rolling Wood Doors

The Rolling Wood Doors, made by the J. G. Wilson Corporation specially for closing engine houses, are of wood slats 2½ in. wide and 1¼ in. thick, fitting together with rule joints, edge to edge, and threaded upon bands of bronze metal, running from top to bottom and spaced 18 in. apart. Each band is riveted to the top slat and attached at the bottom to a strong spiral spring anchor of phosphor bronze concealed in the baseboard or bottom bar which is built up of three thicknesses of ⅞-in. lumber. The entire construction is exceptionally heavy and durable and will stand hard wear.

Special attention is called to the bronze metal extension bands holding the slats together. The spring anchors extend when the door is rolled up and hold the slats close together, while at all times permitting the swelling and shrinkage of the wood slats occasioned by the variations in atmospheric conditions. The slats are not fastened to these bronze bands, but are merely threaded upon them, so that if one or more slats are injured they can be removed, the remaining slats at once closing the gap and new slats being applied at the top.

THE J. G. WILSON CORPORATION, NEW YORK

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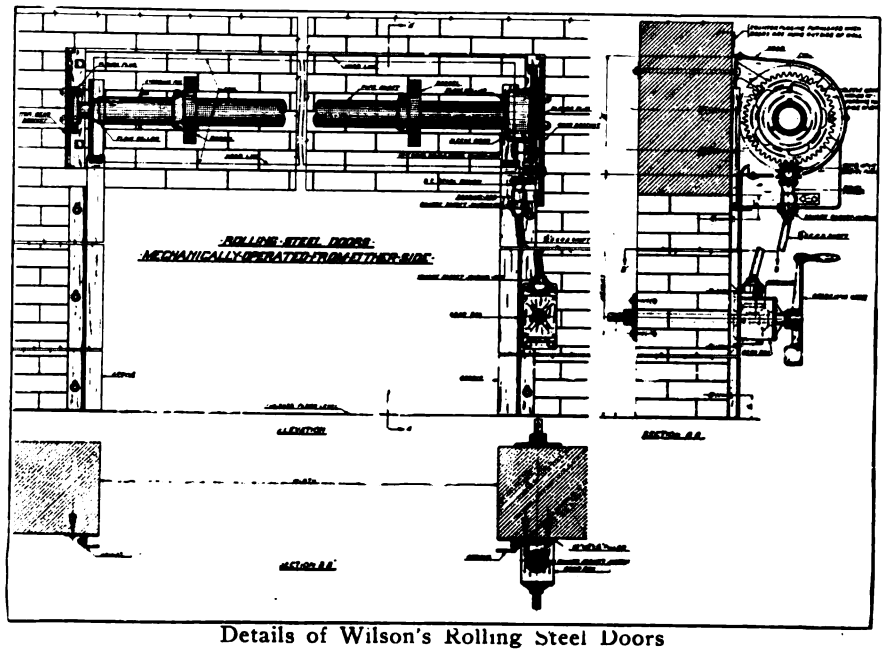
The doors are hung upon shafts about 6 in. in diameter in which are placed one or more helical springs arranged to counterbalance the weight of the door. As these springs are practically sealed up in the iron shaft, they are protected from destructive fumes. The door is raised and lowered with great ease by an endless galvanized chain attached to a simple gear at the end of the shaft, or, if desired, it can be operated by a small electric motor. The door can be raised in 20 sec. with a pull upon the operating chain of about 20 lb., the weight of the regulation size of roundhouse door being 700 lb.



Details of Wilson's Rolling Steel Doors

Rolling Steel Doors

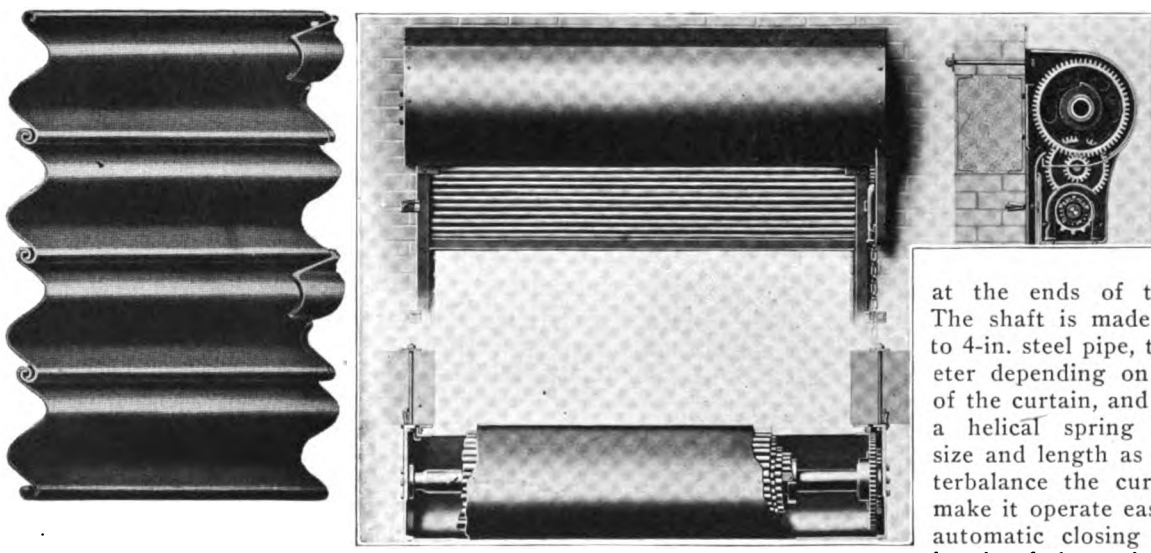
The steel rolling door possesses many advantages for freight houses besides the architectural feature of closing the wider openings securely against burglary, and affording convenient access for the receipt and delivery of goods.

The Interlocking Slat Rolling Doors and Shutters, Style No. 4, are designed to secure the maximum of lateral strength and resistance to wind pressure. A square foot of slate contains two square feet of steel disposed in such a way as to avoid all sharp bends, thereby adding greatly to the durability of the door. The slats are in Nos. 22, 20, 18 and 16 U. S. gauge. In selecting the thickness of slat required for a particular job it should be remembered that the shape of the slat has much to do with the lateral strength and durability of the door and that an increase in the thickness of the steel is not necessarily the solution of the problem. The new anchor devices, placed on each side of the door and two or three feet apart, are effectual in preventing the door from being blown out by the wind in a heavy gale and avoid the necessity of employing deep grooves for this purpose.

Wilson's Fire Doors

In its general design and construction Wilson's Rolling Fire Door is a single door, spring counterbalanced, and is built for openings not to exceed 12 ft. wide or 12 ft. high in an elevator shaft. It is mounted on the face of the walls and overlaps at the sides and top, being operated manually by a handle placed on the bottom bar of the curtain or closed automatically by a releasing device actuated by a fusible link.

The curtain is made of interlocking slats formed of No. 20, U. S. gauge galvanized open hearth steel. Each end of each slat is provided with a special malleable iron end lock, riveted to the slat, which is designed to take the wear in the grooves, maintain tightness in the joints between the slats, prevent lateral motion of the slats and act as fire stops at the ends of the slats. The shaft is made of 3-in. to 4-in. steel pipe, the diameter depending on the size of the curtain, and contains a helical spring of such size and length as to counterbalance the curtain and make it operate easily. The automatic closing mechanism is of the spring-release and stop-nut type.



Wilson's 2800 Rolling Steel Door

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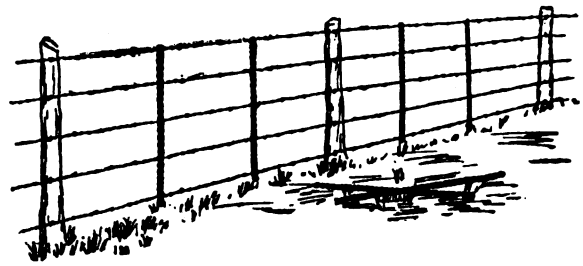
FENCE STAYS

General

The continually increasing costs of railroad operation necessitate the practice of rigid economy in all items of expenditure today. Any element, therefore, which lowers the cost of constructing or maintaining a structure, or makes it serviceable for a longer period, deserves earnest consideration. Because of the large sums which are spent annually for extensions and renewals of right-of-way fences, the railroads have found it profitable to make a careful selection of the materials entering into this structure.

The Worth Wire Works, Kokomo, Ind., makes a specialty, the Cinch Fence Stay, which is used extensively on the railroads to reduce the cost and increase the durability of the right-of-way fence. The stay ties the strands of a wire fence together at points between the posts, and not only helps to support the fence as a whole, but makes it impossible for the strands to spread apart, and thus create an opening through which stock may emerge upon the right of way. A single line wire detached from the post, or a broken one, thus does not destroy the effectiveness of the fence in turning cattle. The cinch fence stay is standard on a large percentage of the railroads operating in the middle, western and southern states.



Fence Equipped with Cinch Fence Stays

Fence Stays

Fence stays are primarily fence stiffeners. They are fastened in an upright position to the fence at each separate strand and are inserted at as many points between the posts as may be desirable. The addition of stays has many advantages, chief among which is the ability to space the posts farther apart, thereby reducing the number of posts required for a given length of fence. With material expensive and often difficult to obtain, a saving of this kind is of importance, especially where the construction of much fence is necessary.

Other advantages indirectly accrue from a saving in the number of posts. There are fewer holes to be dug, and in almost any ground this is an item of no small value. Further, the labor of handling and setting in place the additional posts well may be considered. The saving in these items applies not only to the new fence constructed, but to its future maintenance as well.

The use of fence stays also increases the effectiveness of the fence. A right-of-way fence is built to prevent encroachments, to protect the public from the results of unintentional trespass, but especially to keep stock from getting upon the tracks. To function properly it must be kept intact at all times. A fence that is broken down or sagging badly at one point may thereby become ineffective for a long distance on either side of the break. Thus, the expenditure for the entire fence will become vitiated, protection from straying stock be lost and losses for cattle killed be entailed.

Fence stays are also a means of preserving the attractiveness of a wire fence, avoiding the unsightly appearance when the wires sag unevenly. The economy resulting from the use of stays, aside from their utility in the fence construction, is shown by the decreased wear of the wires where they are stapled on the posts, since the vibration of the individual wires from the action of the wind is thereby greatly reduced.

The presence of fence stays increases the durability of a wire fence by making it a uniform structure. A well-stayed fence offers resistance to wear and to the breaking of individual wires, because the force applied to any single wire is distributed by the stays to all the other wires. This prevents a common form of failure in wire fences, individual strands broken here and there and falling to the ground.

The life of a fence is thus increased by the use of fence stays and the maintenance expense is similarly lessened. The wires remain taut for a longer time and fewer of them break in service. A supplemental advantage is the greater visibility afforded, preventing stock from running headlong against the fence, which often is a factor in its early destruction.

Cinch Fence Stays

The Cinch Fence Stay is a wire made of No. 10 gage hard steel, galvanized, which is bent double and twisted throughout its entire length. It is applied to the wire fence by slipping the open end over the top line wire and is then "cinched" or fastened to each line wire in turn. The two strands of the stay are twisted about each other to and including the successive wires, somewhat in the manner of forming a simple plait.

The stays are made from 24 in. to 60 in. in length, and are assembled in lots of 100 each. As the stays consist only of a section of plain wire, without clamp or other fastening device, the cost is comparatively small. In the building of much fence the low expense for this advantage will effect a material saving in the total expense of construction.

The ease and rapidity with which the Cinch fence stays can be applied are further advantages in their use. No tools are required other than a pair of pliers or a claw hammer, and a common laborer can put them on readily with his hands if no tool is available.

The particular advantage of the Cinch Fence Stay over a simple wire clamped to the strands is the double stiffness supplied by the twisted strand of wire. The fact that the stays are definitely secured to each line wire makes it impossible for the wires to move from their established positions. The twisting of the wires offers a non-corrosive sloping surface to the weather and this feature tends to prolong the life of the fence and reduce maintenance.

WORTH WIRE WORKS, KOKOMO, IND.

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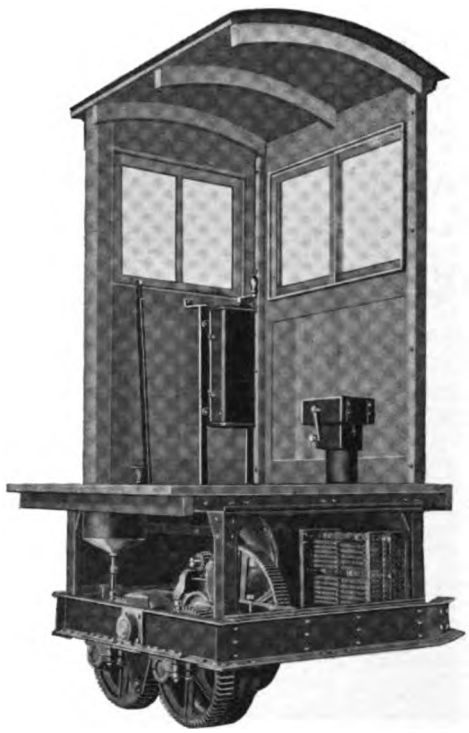
General

The R. W. Young Manufacturing Co., Chicago, manufactures locomotive turntable tractors for compressed air, gasoline or electric power. In the development of these tractors the company had in mind particularly the needs at the large terminals where heavy equipment must be handled promptly and rapidly, and where the tractors are usually operated by unskilled and often careless attendants. Among the railroads using these tractors at present are the Chicago, Rock Island & Pacific; Cleveland, Cincinnati, Chicago & St. Louis; the Seaboard Air Line; the Pennsylvania Lines; the Virginian; the Atchison, Topeka & Santa Fe; the Baltimore & Ohio; Union Pacific; and the Wabash.



Sectional View R. W. Young Turntable Tractor

R. W. Young Electric Tractor

The tractors consist essentially of a D. C. or A. C. reversible motor in compact arrangement with gear transmission and two traction wheels, the motor and all mechanism excepting the main line switch, brake lever, sanding lever and controller (which is of the variable speed type) being enclosed by steel sheets and carried on a frame which is connected to the turntable by a sliding coupling. Each tractor is built to suit the local conditions and is equipped with a collector for the center of the table (adapted for installation below the ties or overhead on a steel support), the necessary wire, conduit and fittings to carry the current from the collector to the controller and motor, also extra heavy cast iron grid resistor, drum brake on the intermediate gear shaft, sanding device, and operator's cab with proper lights.

Embodied in these machines are a number of features which merit special attention, among which are the employment of two traction wheels and the sliding turntable connections. By reason of these connections the tractor is permitted to stand on the circle track practically as an independent unit, thus, on the one hand, preventing vibration and shock from the table from reaching the tractor and thereby breaking grids in the resistors, loosening electrical connections or holding bolts, and on the other hand, operating jointly with the two traction wheels to prevent slipping, inasmuch as the sliding connection eliminates any lifting effect on the tractor by the rising of the turntable..

The tractors are also distinctive in that all parts which may require renewal, such as the controller, motor, gears and wheels, are of standard design, by reason of which repair parts can be obtained readily. The gears are of cast steel with forged steel pinions, and the driving gears are made about 2 in. smaller than the traction wheels to prevent them from coming in contact with the rail. Both driving gears and wheels are keyed and pressed on their shafts. All bearings have removable caps, lined with babbit or bronze bushings, and are attached to the frame by through bolts, the flanges of the supporting channels being reinforced at these points.

Another feature of the machines lies in the construction of the main frame, no wood entering into the construction, or any bolts, excepting those required to attach the "A" frame, the upper portion carrying the cab as well as that supporting the machinery being riveted, thus eliminating the distortion sometimes encountered in tractor service. Adequate provision is made in the arrangement of the machinery for inspection and lubrication, the sheet iron housing at each end of the frame being made to slide for the purpose, and ample provision is made for the removal of the motor sidewise.

The construction of the brake is simple and durable, being composed of heavy cast iron shoes in which are inserted replaceable maple blocks, which engage the cast iron brake drum. The sand box is of generous proportions, has a sloping bottom, and is controlled by a simple plug valve operated by a foot lever in the cab.

The collector is enclosed in a heavy cast iron case, instead of sheet iron, and is completely waterproof. As a means of avoiding trouble from arcing due to vibration, the collector rings slide upon each other and are held in place by springs.

With the aim of providing proper safety for the operator and at the same time furnishing protection to the motor, the electrical equipment includes a three-pole magnet switch with holding attachment and gravity reset overload relay having a special controller with contacts only in the off position. Between this controller and contact switch is interposed a push button which is closed by the operator when he is in the position to swing the turntable. If for any reason he leaves this position or if an overload is applied to the motor, the switch will throw out, thereby cutting off the current until the handle of the controller is returned to the neutral position.

The R. W. Young Company is prepared to furnish a man to supervise and assist in installing a tractor, or will furnish detail plans, as desired.

R. W. YOUNG MANUFACTURING CO., CHICAGO

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